# AN INQUIRY INTO THE LAWS OF ANIMAL LIFE;

BEING

AN ANALYSIS OF THE PRINCIPLES OF MEDICAL SCIENCE,

WITH A VIEW TO OBTAIN

MORE SATISFACTORY EXPLANATIONS OF THE PHENOMENA THAT PRESENT THEMSELVES IN HEALTH AND DISEASE.

PART THE FIRST.

TO WHICH IS PREFIXED,

A General Outline

OF

THE ORGANS AND FUNCTIONS

OF THE HUMAN BODY.

BY

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PRINTED FOR T. UNDERWOOD, FLEET-STREET, LONDON,

BY G. F. HARRIS'S WIDOW & BROTHERS, LIVERPOOL.

1812.

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# PREFACE.

THE acknowledged inadequacy of the sciences of physiology and pathology to account satisfactorily for many interesting phenomena that present themselves, both in health and disease, implies a distinct avowal, that the received principles of these sciences must either involve some radical defects, or that other principles still remain undiscovered, whose influence tends to modify our results and perplex our reasonings.

To detect, by a more careful analysis, the sources of fallacy in the former, and by legitimate induction to pave the way to the discovery of the latter, is the design of the following work.

How far the attempt has been successful, it is for the reader to determine. Relying upon his candour, the only indulgence claimed by the author is a suspension of judgment, if the intended application of the new prin-

ciples deduced, and the importance of seemingly slight modifications of the old, should not always at first appear obvious.

The one and the other will be gradually unfolded in the course of the inquiry; and it will eventually appear, that nothing has been introduced that was not essentially necessary to the views that will be subsequently offered.

In a subject so extensive, as to comprise within its limits the investigation of all the phenomena of the living body, the necessity for systematic arrangement needs no illustration. That the solution of the more simple, should in every science precede that of the more complex problems, is too manifest to have escaped the notice of systematic writers. But the difficulty lies in determining what constitute the most simple problems. And to this must be ascribed the want of a more scientific arrangement than has yet been adopted into physiological works; in which the complex functions, such as digestion, are sometimes considered, before the simpler laws of sensation and motion on which they immediately depend. And in general the want of some bond of connexion between the different branches of the subject, gives to the whole a broken and disjointed appearance.

An attempt is made to remedy these defects, by substituting a mode of arrangement that supersedes the necessity of presupposing the reader to be partially acquainted with the subject to be laid before him; and by supplying a connecting link that unites its different branches, and embodies them into a system.

Further it is to be observed, that between the mere description of the functions subservient to life, and the investigation of the laws by which these functions are governed, a marked line of distinction prevails. Blending together the natural history and the philosophy of the animal economy is in itself a material defect; the general connexion and reciprocal dependance of the different functions rendering it indispensible that a competent knowledge of the former should have been acquired previously to entering upon the study of the latter.

And again, the description of the functions cannot be rendered intelligible without that of the organs that perform them. Hence we find, in all systems of physiology, more or less anatomy introduced, as the author may happen to deem it necessary. But if the reader be acquainted with anatomy, why suppose him to know it imperfectly? If it

remain to be taught, why teach it only in part?

To obviate these difficulties, nothing is here presupposed, but an acquaintance with the meaning of terms familiar to every one, the occasional illustrations taken from disease being intended only for the professional reader; and a general outline of the animal economy has been prefixed to the inquiry, with as much of the anatomical structure as was requisite for explaining the functions; the whole being compressed into the smallest compass that appeared consistent with perspicuity.

Another desirable object seems in this way to be attained, namely, bringing the subject more within the reach of the general reader. For although physiology may never become a popular subject, there seems no reason why the philosophical inquirer should be precluded from one of the most interesting and instructive branches of general science. This, however, was effectually done by the difficulties that occur in obtaining a sufficient knowledge of anatomy from works filled with minute detail, designed only for the medical profession.

The more general diffusion of medical science is, on every account, desirable. To

this alone can we look for the extirpation of empiricism, which derives its strongest support from the doubts that continue to prevail with respect to the existence of any science in medicine.

Mystery ever begets distrust; and the surest way to convince the incredulous that medicine is a science, requiring both study for its acquisition, and experience for its application, is to draw aside the veil and court inquiry.

Although the introductory sketch may contain little that was not previously known to professional readers, yet as the author has availed himself of some recent improvements, giving a survey and critique of the system of Bichât, and placing the delineation in the point of view best calculated to throw light on the subsequent reasonings, it is hoped that they may not find occasion to deem their time mispent in affording it a cursory perusal.

One circumstance yet remains to be stated. The work which is now offered to the public was printed a year ago; but the publication was suspended, the author having subsequently formed the design of giving a course of public lectures, which he conceived might thus, in a great measure, be deprived of their novelty.

Having since however extended his views so far as to render the present exposition little more than a syllabus of the first part of his intended lectures, he has no longer any motive for delaying publication, but rather an inducement to accelerate it ; since it is not to be supposed, that a subject so abstruse can be fully comprehended in a single course, without some previous study.

*London*, 17, *Southampton-Row*,
*May* 24*th*, 1813.

A GENERAL

# OUTLINE

OF THE

# ORGANS AND FUNCTIONS

OF THE

# Human Body.

# A GENERAL OUTLINE,

*&c. &c.*

## *Classification of Functions.*

THE functions of the animal body have been distinguished by the French physiologist Bichât into two classes; a division partly founded upon the diversity of attribute that characterises each, and partly upon the difference of structure in the organs that perform them.

One class of organs is subservient to the nourishment and support of the body, enabling it to assimilate and convert into its own substance the materials on which it feeds, and to separate and reject such particles as are no longer fit for the purposes of life. These are functions performed by all organized matter, other animals, and even vegetables, enjoying them in common with man; this class, therefore, Bichât terms the functions of organic life.

The other class of organs is subservient to functions of a more exalted nature, which distinguish man from all created beings. These have respect, as Bichât expresses it,

to man's external connexion with the objects around him, and render him an inhabitant of the world at large, and not, like the vegetable creation, of the spot which gave him birth. They are characterised by the faculties of loco-motion and mind, from which man feels, thinks, and moves, acts according to the impulse of will, and expresses, by voice, his hopes and fears, his pains and pleasures. These he terms the functions of animal life.

Regarding this as a scientific distinction, it is beautiful, and in many respects useful; but if we carry it to the extent that the ingenious author appears to have intended, and regard each as a separate mode of existence, deriving its support from a distinct vital principle, we shall be justly exposed to the imputation of blending metaphysical subtlety with physiological fact.

As Bichât, however, defines life to be the aggregate of functions performed, and not the animating principle that gives rise to their performance, he perhaps screens himself, behind this definition, from the imputation alleged; and the question, whether life result from mere organization, or require a separate immaterial principle to animate the body, being rather metaphysical than phy-

siological, we may leave its decision to others, and proceed to examine the structure and attributes of the organs subservient to each class of functions.

But we are here compelled to admit the inadequacy of science to limit or define the operations of nature; and this classification, however beautiful and captivating, will soon appear defective, the organs and functions of animal and organic life being occasionally transmuted or blended together, so that the division, if minutely examined, will be found not strictly philosophical, because not strictly true.

As an artificial distinction, it may, however, still prove useful, and will be liable only to such objections as may with equal propriety be urged against every attempt to define the operations of nature, which run down by imperceptible gradations in one uninterrupted series from organized to inorganized matter, and rise again as gradually from the lowest germ of conscious feeling to the highest powers of moral reasoning.

By blending the functions and attributes of each class of organs along with the account of their structure, it is hoped that the reader may be partially relieved from the tediousness of anatomical description.

# ANIMAL FUNCTIONS.

## MIND.

The functions of mind have their immediate seat and origin in the brain, from whence issue all the mandates of the will, and in which is concentrated every mental perception of an external impression. This is no hypothetical assumption, but a necessary inference drawn from undeniable facts. We can trace the particular organs through which this communication is kept up; and the instant this is interrupted, all consciousness of impressions ceases, and the influence of the mind over the limb is lost. If it feel, the mind takes no cognizance of the impression; if it move, it is no longer in obedience to the will. It retains only organic feeling and organic motion, of which it does not appear to be immediately deprived, even after its total separation from the parent body.

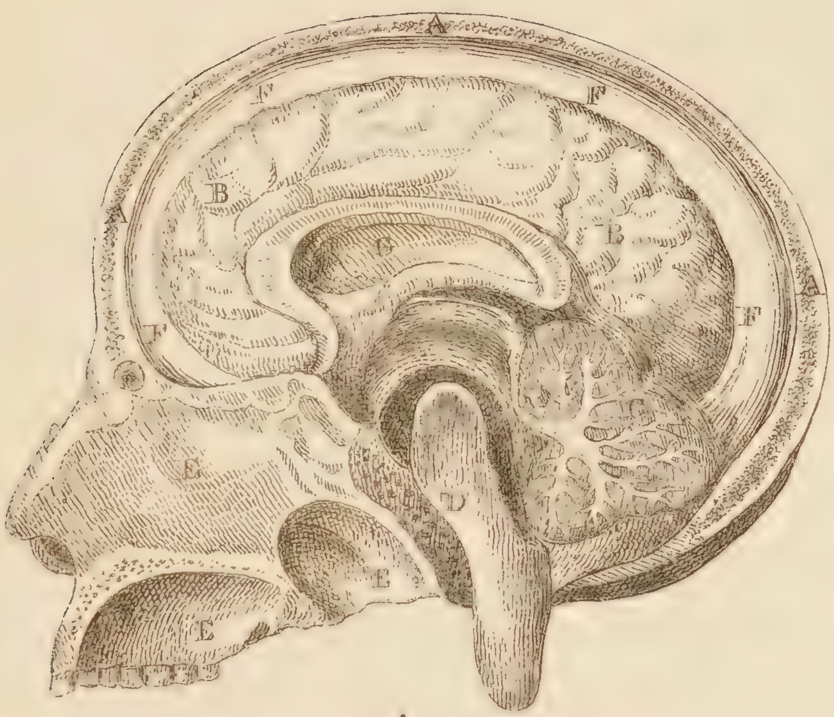
A minute description of the structure of the brain would afford little amusement, and convey little instruction to the reader, as physiologists have been hitherto unable to

assign particular offices to the various parts that compose it: a very general account will, therefore, be sufficient.

The brain is a pulpy mass, situated in the superior part of the cranium, or skull, where it occupies a cavity half as large as the head itself. Its form corresponds to that of the skull, irregularly convex above, and flattened beneath. It is partially divided by a membrane called the falciform process, descending from above, about half through it, and extending from the front to the back of the cranium, dividing it into two equal halves, called hemispheres, each of which exhibits perfect similarity of form. Its substance is composed of six prominences, or lobes, two of which project anteriorly, two laterally, and two posteriorly. At the lower and hinder part is situated a portion which it is of some importance to distinguish, being almost the only part to which experiment warrants our ascribing any peculiarity of function. This is the cerebellum, or little brain, from which a prolongation extends down a cavity in the back bone, hence improperly termed the spinal marrow. Lesion of this part suspends the power of voluntary motion in the organs below the seat of the injury; and when the skull has

been laid open, pressure on the cerebellum excites convulsions; whereas pressure on the cerebrum causes a state of stupor, resembling sleep; from which it appears probable that the cerebrum is more immediately concerned in the function of mind, and the cerebellum and spinal marrow in that of voluntary motion.

The brain is every where surrounded by membranes; the outer one, which lines the inner surface of the skull, termed dura mater; the next, belonging to the brain itself, termed pia mater; and a third called arachnoid, which appears, from more recent observation, to be only a reduplication of the second. Its substance is of a peculiar nature, and cannot be easily described; its colour is whitish towards the centre, and termed medullary, but grey at the edges, hence called cineritious. The cerebellum appears to be formed of similar substance; and, when divided by a vertical section, exhibits a beautiful arborescent appearance, hence termed arbor vitæ. In the substance of the brain are contained four cavities, termed ventricles, and a number of eminences, depressions, sinuosities, and other appearances, minutely described by anatomists; but with the use of which we are wholly unacquainted.



*Etched by S. Yates, L'pool.*

## SENSATION.

From the base of the cerebrum, from the cerebellum and spinal marrow, small white cords, called nerves, proceed; each of which consists of a number of infinitely minute threads, or filaments, which ultimately expand over the different organs endowed with sensation or motion. Each separate cord, or nerve, has a sheath, that surrounds it as it proceeds from the brain; and every separate nervous fibre is supposed to be also enveloped in a distinct membrane of its own. To these threads the organs of sense owe their faculty of feeling; and from these every muscular fibre derives its powers of contracting, as proved by the experiment before alluded to, the division of these nerves suspending the faculties of sensation and motion in the parts with which they communicate.

The cerebral nerves, or those which proceed directly from the brain, amount to ten pairs, corresponding branches issuing from each side. The following is their distribution:

Beginning at the fore part of the base of the cranium, the first pair proceed to the

nose, termed olfactory; the second to the eyes, termed optic; the third pair to the muscles that give motion to the eye-balls, called motores oculorum; the fourth perform a similar office, but are confined to a particular muscle, called patheticus, from its rolling the eye upwards; or trochlearis, from the mechanism resembling a pulley by which this is accomplished. The fifth pair of nerves are called par trigeminum, being composed of three branches; the first, called ophthalmic branch, supplies filaments to the upper eye lid, to the forehead, to the nose, and to some internal parts of the eye; the second branch, called superior maxillary, sends filaments to parts in the vicinity of the upper jaw, to the palate, the teeth, the cheeks, the eye-lids, and sides of the nose; the third branch, called inferior maxillary, supplies parts in the vicinity of the lower jaw, as the cheeks, the lips, the teeth, the tongue, and the chin: the two latter send filaments also to the ear. The sixth pair of nerves, as well as the third and fourth, are subservient to the motion of the eye-balls, being dispersed on the muscles which roll the eye outwards, hence termed abducentes. The seventh pair are composed of two portions; one, from its softness, called portio mollis,

goes to the internal parts of the ear; the other, from its firmness, called portio dura, sends also some filaments to the ear, and likewise to the throat, and to the back of the head, but is chiefly distributed over the face. The eighth pair also consist of two branches on each side, called glosso-pharyngeus and pars vaga; the former sends filaments to the tongue and throat, and the latter also supplies parts in the vicinity of it, and then descends down to the heart and stomach, sending back in its descent a branch called recurrent, which ascends again to the wind-pipe, and is subservient to the organs of voice. The ninth pair are chiefly ramified upon the tongue, and are called lingual, but also send a branch, called descendens noni, to parts of the neck. The tenth pair, from the circumstance of their issuing from the cranium in company with the eighth, are called accessory; they are chiefly distributed to the muscles which give motion to the neck and shoulders.

The spinal nerves, or those which proceed from the spinal marrow, are thirty pairs, one issuing between each joining formed by the pieces that compose the back bone. Those proceeding from the upper part, called cervical, supply the upper ex-

tremities; and from filaments given off by the second, third, and fourth pairs, is formed what is called the phrenic, or diaphragmatic nerve, subservient to the function of respiration. Those of the back, called dorsal, go chiefly to the trunk of the body, and administer to the muscles that give it motion: those issuing from the lower part, called lumbar and sacral, proceed chiefly to the lower extremities, and are subservient to the function of loco-motion.

## MOTION.

The function of motion is performed through the means of muscles, or bundles of fleshy fibres, which cause the limbs to perform their various evolutions when thrown into a state of contraction by the nervous influence. They are supported by, and attached to bones, being distributed over them in successive layers; the external layer giving form and symmetry to the body, which is further improved by the intervention of adipose, or fatty substance, rendering the surface more smooth and even.

The muscles generally arise from one bone, and are inserted into another, causing

the limb to move on the connecting joint with a degree of flexion and extension proportioned to the contraction excited. The internal structure of a muscle resolves itself into a bundle of fleshy fibres, connected together by a thin membranous substance; they are generally thicker about the middle, and smaller towards the extremity, where they collect together into a round tendinous cord, or are united by a strong fibrous membrane, which is inserted into the covering of the bone called periosteum.

Every separate muscular fibre has a distinct covering, of delicate texture, called cellular membrane; and the whole muscle together is enveloped in a covering of the same membrane, which is continually moistened by fluid, serving to lubricate it, and facilitate its motions.

This membrane likewise surrounds every separate organ, and the whole surface of the body; the term cellular being given to it from a number of cells which it forms beneath the surface, and between the different organs, as is discovered by inflating it.

It is probable that every muscular fibre has its corresponding nervous filament, by which its contraction is induced. The natural strength of each muscle seems to depend

chiefly upon the number of fibres collected into a mass, their length appearing rather to determine the extent of contraction of which it is capable.

The function of loco-motion is performed by the muscles of the trunk and lower extremities; the muscles of the breast and shoulder give motion to the upper extremities; those of the shoulder move the fore arm, those of the fore arm move the fingers; the head is supported by those at the back of the neck, while those at the fore part of the neck contribute to give it a rotatary motion; the muscles of the back and abdomen serve to keep the body in equipoise; and every moving organ owes its power of action to muscular fibres; a minute acquaintance with the names and functions of which may be obtained by reference to more voluminous anatomical works, or by actual dissection.

The bones, into which the muscles are inserted, constitute the basis and support of the whole superstructure.

The osseous system is composed of a number of separate pieces, nicely adjusted and connected together by joints, which allow motion to each part according to the extent that is required; the whole forming what

Plate II.

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Etched by S. Yates, L'pool.

is called the skeleton, which exhibits to the eye of the naturalist the most interesting subject for meditation, affording in every part proofs the most convincing of foresight and contrivance.

The internal structure of bone consists of hard compact plate towards the surface, and spongy or cellular texture in the centre. Its substance is composed of an intermixture of earthy and cartilaginous matter, which bears so equal a share in its composition, that the one or the other may be totally removed without materially changing the external form and appearance of the bone. If by combustion the cartilage be destroyed, leaving the earthy matter entire, the bone becomes porous, white, and brittle. If by chemical solution the phosphat and carbonate of lime be dissolved, and the cartilage suffered to remain, the bone retains its form and appearance, but becomes soft and pliable.

In the fœtus the different stages of ossification may be traced, and the process observed which nature pursues in the formation of bone. At first a mere cartilage is found, in which, after some time, a plexus, or network of red vessels appears, shooting out from different points according to the shape of the bone; ossification commencing in some

bones from one, and in others from several points. These vessels at length deposit earthy matter; then become gradually obliterated, and fresh vessels appear, until the whole cartilage is pervaded by vessels, which are successively obliterated by the deposition they make; and thus the cartilage is converted into a solid bone. That it still, however, retains both nerves and vessels to a certain extent, is proved by its extreme sensibility in the inflamed state, and by the constant change and renewal of its substance.

A general idea of the structure and connexion of the human skeleton can alone be offered in a sketch like the present.

The skull, or cranium, forms a complete case of bone, containing and protecting the brain; but perforated by numerous apertures, or foramina, which allow the transmission of nerves to parts subject to its controul, and admit the entrance of vessels which are essential to its support. The largest of these apertures is situated at the base of the cranium, in what is termed the occipital bone, (the cranium being composed of eight separate pieces), and opens into the centre or cavity of the bones of the neck, allowing the prolongation of the cerebellum, termed spinal marrow, to descend down the hollow of the

back-bone, from whence nerves are sent off, as already described.

The spine, or back bone, may be regarded as the pillar supporting the head, the chest, and the upper extremities. It is composed of twenty-four pieces, called vertebræ, connected together by a mode of articulation, that allows them a certain degree of motion; and cartilaginous matter interposed, which facilitates it, and prevents injury from pressure. Of these vertebræ, seven belong to the neck, twelve to the back, and five to the loins: they become gradually larger as they descend, and terminate in what are called the false vertebræ, or sacral bone. The sacral bone is articulated with, and supported by the pelvis, which may be regarded as the base of the whole column. The pelvis, commonly called the hip-bone, is also composed of separate pieces in the fœtus, but becomes afterwards consolidated into one, deriving its name from its resemblance to a basin, and from its office, which is to contain and support the abdominal viscera.

The bones of the lower extremities are affixed to the pelvis externally and laterally; the head of the thigh-bone forming a ball, which is received into a corresponding socket on the

outside of the pelvis; a form of joint well calculated for the kind of motion required.

The chest, or thorax, is formed by the ribs, which proceed from the vertebræ of the back, and meet before in the breast-bone, or sternum, constituting a kind of basket-work, that contains and protects the thoracic viscera. The term thorax is given to the whole space included by the ribs, and that of abdomen to the portion below extending down to the bottom of the pelvis.

The ribs are usually twelve in number on each side; the seven superior, called true ribs, extending round to the sternum, to which they are united by cartilage; the five inferior, called false ribs, four being connected to each other and to the last true rib by means of intervening cartilage, the fifth floating loose. The articulation of the ribs with the vertebræ of the back allows a degree of motion, which contributes to the function of respiration. Each rib being placed in a direction sloping downwards, and extending somewhat wider than the one above it, the capacity of the chest must necessarily be enlarged or expanded by raising the ribs, which are all connected together by muscular fibres, called intercostal.

Plate III.

P. 18.

Etched by S. Yates, L'pool.

The upper extremities are affixed to the back by large flat triangular bones, termed scapulæ, or shoulder-blades; which are simply applied to, and retained in their position by the surrounding and connecting muscles. At the extremity of the shoulder, the end of the scapula meets, and is articulated with a small bone, proceeding from the forepart and top of the sternum, called clavicle, or collar-bone, which regulates and confines the motions of the scapula, and serves to keep it at a suitable distance from the chest. The bone of the arm is attached to the head of the scapula; the round head of the os humeri, or shoulder-bone, meeting with a corresponding cavity, or depression, at the extremity of the scapula, which allows the greatest extent of motion.

Few points display the admirable contrivance of the human frame more conspicuously than the joints; but a minute description of them would encroach too far upon the limits of a sketch which is intended to convey only a general idea of the structure of the organs.

As an instance of the beautiful mechanism alluded to, it may be sufficient to describe the mode in which the head is affixed to the vertebræ of the neck, so as to allow either the motion of flexion and extension, or the

rotary motion on its centre, without interference or derangement.

The first vertebra of the neck, termed atlas, from its supporting the head, is joined to it somewhat after the manner of a common hinge, allowing the face to be raised upwards, or bent down forwards, with perfect ease.

The second vertebra, called dentata, has a process, or tooth, about half an inch long, standing upright, upon which the atlas is fixed by a corresponding cavity, and rests as upon a pivot, turning along with the head to the right and left, as far as the connecting ligaments allow it.

By these means are the two motions combined, and the vertebra dentata is again connected with the one below it by the common articulation, a limited degree of motion being allowed to it in common with each succeeding piece in the descending column.

Every joint in the body is furnished with ligaments, or cords, connecting the bones together, and preventing dislocation; and each has besides a double membranous covering, called sinovial; one fold of which adheres to the surface of all the bones of the joint, and the other forms a loose covering which envelopes the whole joint; both together forming, when detached, a complete

sack. The inner surfaces of this capsule are smooth, and exhale a thin unctuous fluid, which lubricates the joint, and prevents friction.

This short sketch may serve to convey a general idea of the organs subservient to voluntary motion. After giving a description of the organs of sense, we shall proceed to the functions of organic life, which are more immediately concerned in physiological and pathological enquiry.

## VISION.

The organs of vision are nearly spherical, and composed of different humours to transmit and concentrate the rays of light; of membranes to surround and contain these humours; and of muscles affixed to the external surface of the globe to give it motion. The whole apparatus is seated in, and protected by a corresponding cavity, or socket, formed by the base of the cranium and the bones of the face. The sense of vision is excited by the impression of light impinging upon the optic nerve expanded over the inner surface of this globe. The rays of light are admitted thro' a small aperture in the centre of the eye,

called the pupil, which is so constructed as to accommodate its dimension spontaneously to the quantity and intensity of light that enters the eye.

The membranes surrounding the eye are three in number. The outer, termed the sclerotic, is of fibrous texture, and serves to give strength and solidity to the whole; and to it the muscles are attached which move the eye-ball. This membrane does not form a complete sphere, but leaves a section, or circular aperture, in front, which is occupied by the cornea, a transparent horny substance, commonly called the apple of the eye, which is more convex than the rest outwardly, but concave inwardly. Its office is to protect the pupil, which is placed behind it, without obstructing the transmission of the light, which it assists in refracting. The edges of the cornea are firmly united with the adjoining edges of the sclerotic coat: its degree of external convexity modifies the powers of vision, rendering one person far, and another near-sighted.

Within the sclerotic is another membrane, called choroid, which is of more delicate texture; it is covered internally with a dark coloured pigment, which prevents reflection within from rendering vision indis-

tinct. This membrane, like the sclerotic, does not form a complete sphere, a section opening in front for the iris, which is placed directly behind the cornea, and its edges attached to the corresponding edges of the choroid coat. The iris is supposed to consist of two sets of fibres connected together; one inner and circular, like a ring, which by contracting diminishes the aperture; the other outer, and branching off from the former like the radii of a circle, which by contracting expands the pupil.

Over the inner surface of the choroid is spread the last and most delicate membrane, called retina; consisting of an expansion of the optic nerve, which proceeds from the brain through a foramen at the bottom of the socket of the eye, and enters obliquely at the back of the eye-ball. This membrane is white, and from its extreme sensibility, receives and conveys to the mind the impression the light makes upon it. The rays of light penetrating the cornea, and passing the pupil, form a distinct representation of external objects, in an inverted picture, which may be exhibited by dissection, as it appears on the surface of the retina.

As the light requires to be refracted and brought to a focus, this is chiefly accomplished

by means of a small round lens, resembling the double convex glass of a telescope, called the crystalline lens, having the anterior surface less convex than the posterior, its magnitude being somewhat larger than the dilated pupil, and smaller than the cornea. It is placed directly behind the aperture of the iris, and refracting the rays of light, causes them to converge into a point before they reach the retina, and thus the representation is inverted, but rendered more distinct.

The loss of transparency in the chrystalline lens is a frequent cause of blindness, constituting the disease termed cataract, which is remedied when the lens is removed by an operation called couching; its office being in a great measure supplied by artificial glasses. Loss of sight occurs also from lesion of other parts of the organ.

The whole cavity of the eye is filled by fluids, termed the aqueous and vitreous humours, which preserve its globular form.

Besides the membranes already mentioned, it has another externally affixed to it, called conjunctiva, which secretes a thin mucous fluid, and serves to protect, lubricate and cleanse its anterior surface. This

*Plate IV.*



*Fig. 1.*


*Fig. 2.*

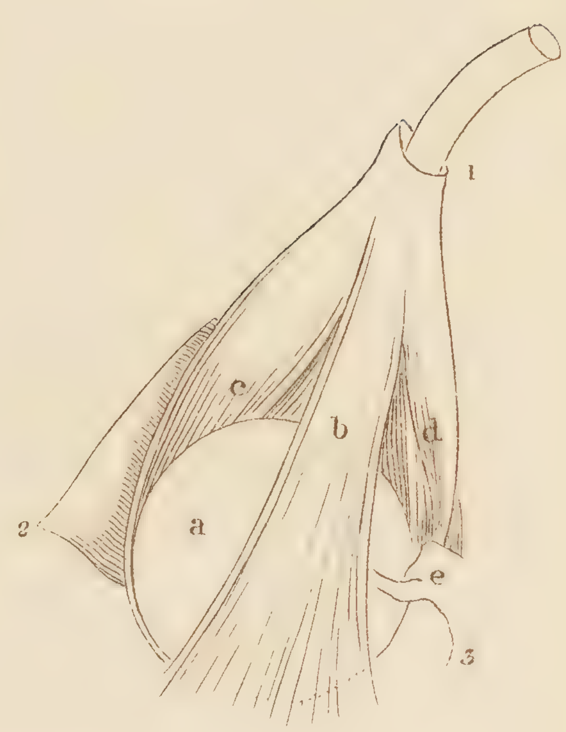



*Fig. 3.*

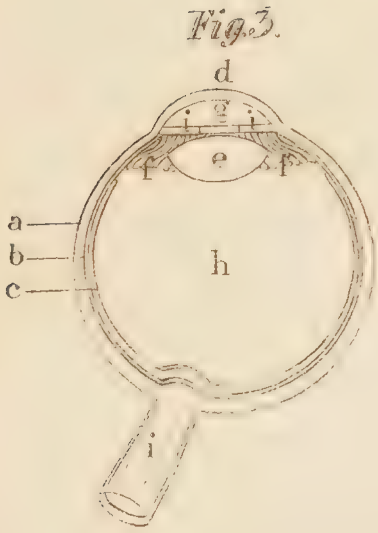



*Fig. 5.*


*Fig. 7.*


*Fig. 4.*

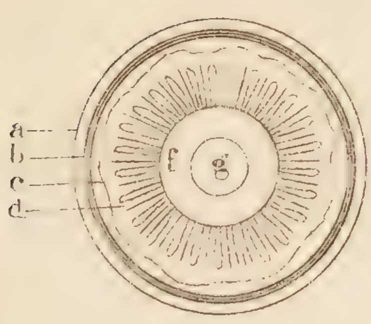



*Fig. 6.*

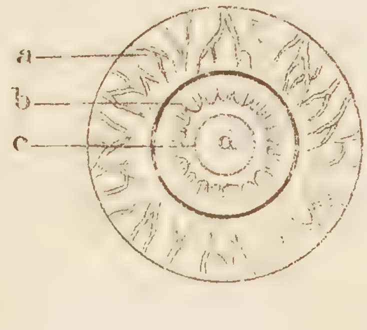
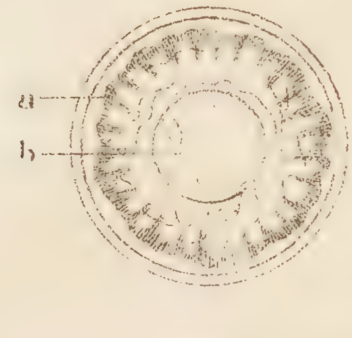



*Fig. 8.*




*Etched by S. Yates, L'pool.*

membrane covers what is commonly called the white of the eye, and is then reflected upwards and downwards over the inner surface of the eyelids, thereby closing the entrance into the socket, and serving as a curtain to prevent the admission of extraneous bodies. The superfluous moisture secreted from it is carried away by small perforations on the edges of the eye lids, termed puncta lachrymalia, which terminate in a duct leading to the cavity of the nose.

The eye is further lubricated by tears, which are secreted from the lachrymal gland, placed in the upper and outer corner of the socket of the eye, which pours out its fluid by numerous small apertures or ducts on the inner surface of the upper eye-lid.

The eye thus organized is enabled to perform the various operations of the most complex optical instrument, adapting itself instantly and with equal facility to the degree of light required, to the distance and magnitude of the objects looked at, and the plane of vision to be surveyed ; and constitutes, as an elegant theological writer remarks, when taken singly and individually, an incontrovertible proof of the contrivance and workmanship of creative wisdom.

# HEARING.

Could we as perfectly understand, we should no doubt find equal reason to admire the aptitude of the different parts of the organ of hearing, for the functions they have to perform. But we are not sufficiently acquainted with the theory of sound, to explain the advantages derived from the peculiar form of the minute cells and cavities which enter into the composition of this organ.

The immediate seat of the sense of hearing is the auditory nerve, or the portio mollis of the seventh pair, expanded over the surface of a number of minute and intricate canals, formed in the substance of one of the bones of the cranium, called the temporal bone. This bone at its lower extremity has a projection running inwards to the base of the skull, the situation and direction of which may be readily conceived by the course of the external orifice of the ear, at the termination of which orifice the internal organ of hearing is placed.

The particular description of the ear will be rendered more intelligible, by first giving a general idea of the parts that compose it.

These are, the external orifice, or meatus auditorius ; at the bottom of this, a thin membrane, covering the mouth of a small cavity called the drum ; beside which, are placed the minute cavities called the mastoid cells, and the canals called the labyrinth.

We may now proceed to the particular use and description of each, beginning with the labyrinth, which contains the nerves, the immediate seat of the sense of hearing.

The labyrinth is divided into the vestibule, the cochlea, and semicircular canals. The vestibule is a small open space, which forms the porch or entrance to the cochlea and canals. The cochlea is a double spiral canal, like the shell of a snail, winding round two hollow cones or funnels meeting at their apices, the whole being rather larger than a garden pea. The semicircular canals are three in number, beginning and terminating in the vestibule, each forming three-fourths of a circle, their area about large enough to admit the head of a small pin.

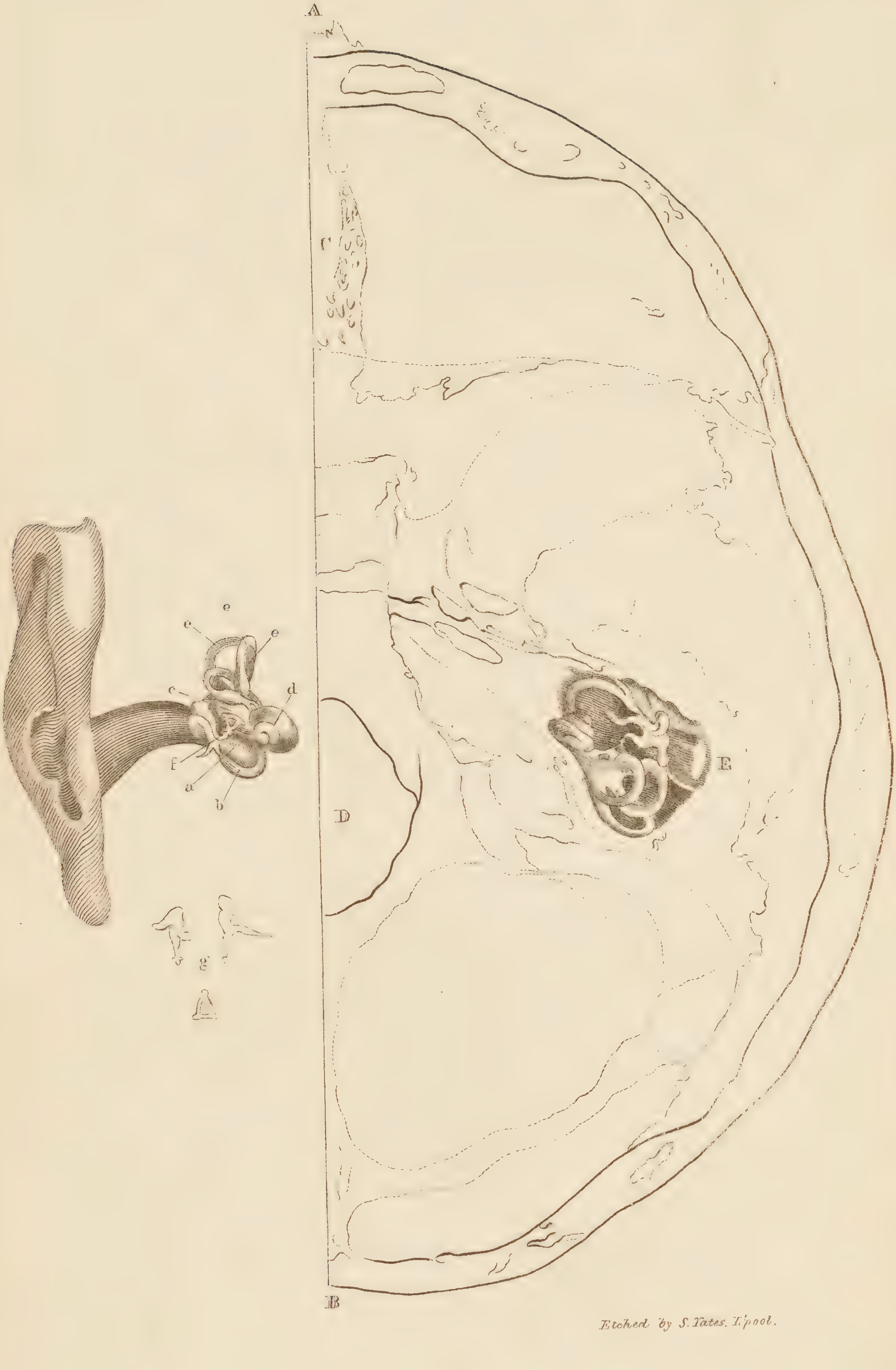
Within the labyrinth a fluid is contained, and the nerves are distributed, which receive the impression communicated by the fluid, when thrown into undulation by the motion of the external air. This undulation is conveyed to the fluid in the labyrinth, through

the medium of the tympanum or drum of the ear.

The tympanum consists of a cavity about half an inch wide, of a semi-spherical form, the mouth of which is covered by a thin membrane extended across it, and inserted into a bony rim, like the head of a drum. This membrane terminates the external orifice of the ear; vibrates with the impression of the air; and communicates its motion to four small bones within the tympanum. The bones are connected together by the extremities; the first of which is affixed to the inner surface of the membrane, and the last is adapted, like the key of a flute, to a small hole opening into the vestibule, termed fenestra ovalis.

The fenestra ovalis and another aperture, called the fenestra rotunda, leading to the cochlea, are both covered by a thin membrane, which prevents the escape of the fluid, but communicates to it the motion received from the small bones, and the air in the tympanum.

In order to enable the membrane to vary its degree of tension, according to the loudness of the sound, or the force of the vibration, it is furnished with three small muscles, which are affixed to the minute bones in such




Etched by S. Yates, L'pool.

a manner, as by their contraction to increase or diminish the tension of the membrane; thus preventing the delicacy of the organ from being injured by too strong a vibration, and augmenting its susceptibility of one that is weaker.

As the rarifaction or condensation of the air in the tympanum might likewise alter the degree of tension, a small canal is provided, communicating with the throat, called, from its discoverer, the Eustachian tube, which keeps up the equilibrium between the internal and external air.

The stoppage of this tube in catarrh, from distension of its vessels, often causes a temporary deafness; and the sudden escape of the air forcing a passage, allows the membrane to recover its position, and is often attended with a crackling noise. Deafness may also arise from injury of the other parts of the ear.

The external ear needs little explanation, being obviously calculated to catch the vibrations, and direct them towards the tympanum. In a state of nature, the external ear or auricle, as it is called, stands more erect from the sides of the head, and is thus better adapted to its purpose.

## SMELL.

The structure of the internal organ of smell is less complex than that of the organ of hearing. It consists in an expansion of the olfactory nerves, which issue from the brain at the fore part of the base of the cranium, by a number of small apertures, perforating the bone like a sieve, whence it has been denominated the cribriform plate. The nerve is then ramified over an extensive surface, formed by four delicate bones of a spongy texture, situated in the cavity of the nose, and dividing it into different passages; of which two run upwards to a cavity formed by the base of the frontal bone, two lead to other cavities formed by the maxillary bones, and two run horizontally backwards, leading to the throat. All these cavities are covered with a membrane that secretes a mucous fluid; and so are also the four spongy bones, which seem to be more immediately subservient to the sense of smell; the olfactory nerves being extensively ramified over their surface, which, from its constant moisture, is well adapted to favour the action of the minute particles con-

tinually exhaled from the surface of odoriferous bodies. In animals that possess a more delicate sense of smell, considerable diversity may be observed in the form and structure of the spongy bones, which are much larger in some, and afford a more extensive surface. The cavities, or sinuses, seem less essential to the organ of smell, but have considerable influence in modifying the tone of voice.

## TASTE.

The organ of taste has a close affinity with that of smell; the one being adapted to the impression of substances in the state of fluidity or solution, and the other in that of vapour, and both have their seat in a mucous membrane. The immediate organ of taste is the gustatory nerve, probably from the third branch of the fifth pair ramified on the mucous membrane covering the tongue; the numerous papillæ observable on its surface appearing to be a peculiar organization, calculated to modify the impressions received. They may be observed to vary in their size and structure in different parts, as the sides, the tip, and the root of the tongue; and this variety may probably have some

connexion with the circumstance frequently noticed, that particular substances make a stronger impression, or sometimes act exclusively, on separate portions of this organ.

The influence of moisture in contributing to the faculty of taste, is evident from the loss of this sense when suppressed secretion leaves the surface of the mucous membrane dry: and some connexion appears also to prevail between the sense of taste and that of smell, as the loss of the latter in catarrh, or its suspension by stopping the nose, considerably impairs the former.

## TOUCH.

The organ of feeling may be regarded as extending over the whole body, but more particularly belongs to the extremities of the fingers. The nerves, which are the primary organs of feeling, are distributed on the skin, a membrane regarded by the French anatomist Bichât as essentially the same with the mucous membrane lining the internal surfaces, being modified chiefly by the action of the air. Thus in the fœtus, as he observes, the skin has the appearance and properties of a mucous membrane; and other mucous

membranes, when exposed to the air, soon assume the character of skin.

A partial analogy, both in structure and function, may then be traced between the organs of smell, of taste, and of feeling; that of smell, from its superior delicacy, is calculated to perceive the impressions of gaseous substances; that of taste has less delicacy, and is adapted to the impression of such as are in a state of fluidity; while the grosser organ of feeling, from the coarser texture and dry surface of its membrane, is best fitted for the impression of solids.

## VOICE.

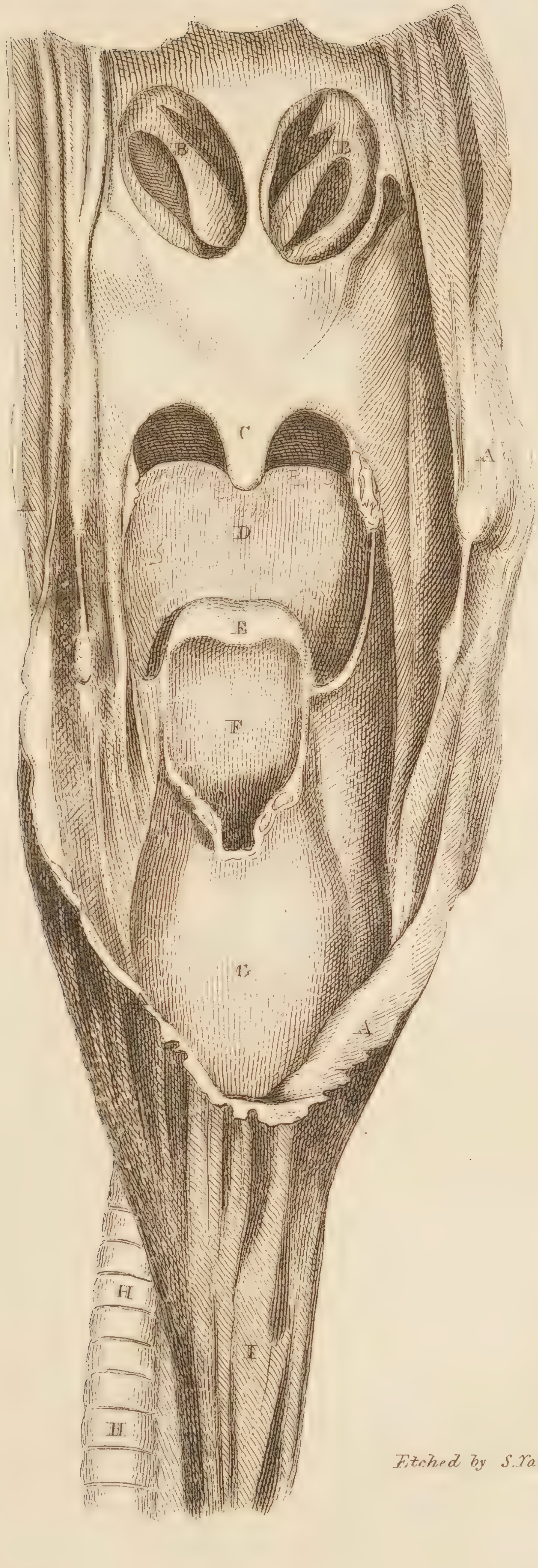
The last of the functions belonging to animal life that remains to be described is that of speech, which depends upon the combined influence of the lungs, the trachea or windpipe, the larynx or throat, and the mouth.

The structure of the lungs will be explained hereafter. The trachea is an open tube descending into the lungs, in which tube the sound is produced. It is composed of a number of cartilaginous rings connected together, each ring forming about three-fourths of a circle, a portion being supplied at the

posterior extremity of each by muscular fibres, which answer the double purpose of yielding to the pressure of the food passing down the œsophagus, or gullet, into the stomach, and of enabling the trachea to diminish its area by the contraction of these fibres. For the same purpose it is also furnished with a muscular coat, composed of two sets of fibres, of which one is circular, the other longitudinal: by means of these, the length and capacity of the trachea admit of being varied to a considerable extent.

The entrance to the trachea or the larynx is composed of a number of cartilages, ligaments, and muscles, forming an aperture somewhat triangular, which admits of an infinite variety of changes, both in shape and dimensions. The aperture is covered by a small cartilaginous body, called epiglottis, projecting backwards from the root of the tongue like a valve, which shuts instantly with the effort of swallowing, thus preventing the food from gaining admission into the trachea, but allowing free passage for the air to and from the lungs.

When the air, in passing over the unequal surface of the trachea, is partially impeded in its escape by the contraction of the glottis, it is thrown into vibratory motion, and pro-




*Etched by S. Yates, L'pool.*

duces sound, which may be modified in an infinite variety of ways by the endless changes which the trachea and larynx are capable of undergoing, both in form and dimensions, and by the different degrees of force and velocity with which the air is impelled through them.

While sound is thus produced and modulated by the action of the trachea and larynx, pronunciation or speech is effected by the joint operation of the tongue and the lips; and if the organs of voice were compared to a musical instrument, as an organ, the lungs would correspond to the bellows, the trachea to the pipes, varying in form and dimensions, the larynx and epiglottis to the stops, and the tongue, throat, and lips, to the keys.

This short sketch may convey an idea of the organs of animal life, a class of functions which Bichât conceives to be characterised by the following peculiarities:

The organs that perform them are twofold or double; thus a vertical line drawn down the middle of the body may divide it into two equal halves, and those organs which are not merely separated by it will be divided into corresponding parts, and perfect similarity of form will be found to prevail in each. This division is also observable in

disease, one entire half of the organs of animal life being often affected in paralysis without material participation of the other. The functions performed by them are attended with consciousness in the mind, and their actions are subject to the influence of the will. They require cultivation from time and experience to bring them to perfection, and their exertion demands the alternate condition of motion and rest, being incapable of long continuance without the renovation derived from food and sleep. The functions of organic life are stated to differ in all these particulars:

The organs performing them are either single, or want that similarity of form observable in those of animal life. Consciousness does not attend their impressions, nor are their actions subject to the controul of the will. They admit of no improvement from practice and experience, respiration, circulation, digestion, &c. being performed by the infant as well as by the adult. Lastly, they do not require the regular alternations of motion and rest, but continue without interruption from life to death.

These are the grand distinctions between the two classes; how far they are strictly correct will be more particularly enquired into

hereafter; when it will perhaps appear that this, like every other artificial distinction, is subject to several exceptions, or true only to a certain extent.

## ORGANIC FUNCTIONS.

This division, as before stated, is partly founded on the anatomical structure and arrangement of the organs, and partly on the peculiarities characterising the functions they perform. Those of animal life, chiefly distinguished by the attendant circumstances of consciousness and volition, owe their origin to the brain and connecting nerves. But those of organic life, characterised by feeling that is unaccompanied by mental perception, and motion that is independant upon the will, such as that of the heart and arteries, of the stomach and intestines, are supposed by Bichât, and with apparent reason, to derive these faculties from another source.

# ORGANIC FEELING AND INVOLUNTARY MOTION.

In different parts of the nervous system hard knots or enlargements of a peculiar kind are observed, which anatomists have termed ganglia; and as they are found to prevail more especially in the vicinity of involuntary organs, it had long been suspected that they had some connexion with the peculiar nature of these functions. Some have regarded them as a kind of barrier that served to intercept the transmission of impressions received by these organs, so as to retard or prevent the changes from exciting perception in the brain, while they were at the same time supposed to equalize the flow of the nervous energy to these organs, and thus prevent the regularity of their action from being disturbed by the varying impulse of the will. But more recent experiments and observations seem to countenance the opinion formerly suggested by Winslow, and entertained by Bichât, and made the principal basis of his division of the functions, that they should be regarded rather as so many separate and

independant reservoirs of nervous energy, or each a little brain performing an office analogous to, though not identical with, that of the encephalon—administering to that peculiar modification of feeling and motion which is unattended with volition and mental perception.

The formation of a fœtus and its growth to maturity, where in some cases there has not been the least appearance of encephalon, or even of the head itself, is one argument adduced in favor of this opinion.

Without, however, entering into the merits of the hypothesis which ascribes their vitality to a separate principle, and without absolutely asserting that Bichât maintained this doctrine, we may venture to infer, from a variety of facts and experiments, that the ganglia do constitute such a peculiar organization of nerves, as gives rise to that modification of feeling and motion termed organic.

A particular description of the situation of the different ganglia, which are very numerous, or of their general connexion by nervous filaments, would be inconsistent with the design of a mere outline. It is sufficient to observe, that such a connexion does prevail, the different viscera being chiefly connected by what is termed the splanchnic

nerve, and the ganglia being also connected with the sensorial system of nerves, by means of what is termed the great sympathetic, from its supposed influence in contributing to the general participation of the whole system in local affections.

The great sympathetic, the medium of this connexion between the brain and ganglia, is a small branch running in the direction of the spine, receiving filaments from, or giving them to, three ganglia situated in the neck, and others placed at the head of each rib, where the spinal nerves issue from the back bone. It also gives to or receives filaments from the second branch of the fifth, from the sixth and others of the cerebral nerves, thus forming a connexion between the nervous systems of animal and organic life.

The splanchnic is formed by branches from the sixth, seventh, and eighth dorsal ganglion, and sometimes from one or two of those above. It also gives or receives branches from an important ganglion, called semilunar, thus forming a connexion between the principal parts of the gangliac system.

The question seems upon the whole of little importance, respecting the propriety of regarding one part of the nervous system as

the root, and another as branches springing from it ; in what relates to function all are alike endowed with life ; and with respect to growth, there is no reason to suppose, that the different parts of the animal, like those of the vegetable structure, must grow in succession ; and such analogies are, for the most part, vague and unphilosophical.

The semilunar just mentioned is the most considerable of the ganglia ; it occupies a central situation in the abdomen, and is connected by numerous filaments with the heart and stomach, the two most important of the organic viscera; all of which, however, are connected with some part of the gangliac system. But whilst we can only form a probable conjecture of the general office of the whole, a minute account of the arrangement and distribution of each ganglion will contribute little towards throwing light on the peculiarities of different organs.

The internal structure of ganglia presents nothing very peculiar to the eye of the anatomist : it appears to consist of a convolution of minute fibres, and some of the larger present the appearance of a pulpy substance in the centre, like that of the brain.

## CIRCULATION.

Circulation is deservedly regarded by physiologists as the first and most important of organic functions, on account of its administering directly to the support of every other, animal as well as organic. It is performed by the heart and blood-vessels; the former seated near the centre of the chest, and the latter distributed over the whole body.

The heart is a strong muscular organ, enveloped by a dense membranous sack, called the pericardium, covered also by a fold of the pleura, which will be described hereafter. It contains within it two distinct cavities, called ventricles, with a kind of entrance or anti-chamber to each, called its auricles, the use and end of which arrangement will be explained by the following circumstances:

The blood has to perform two distinct circuits; one of which pervades the whole system in general, administering nourishment and support to every organ; and the other, which goes to the lungs, not for the purpose

of nourishment, but for one which is to be explained.

The former circuit is not accomplished without the production of certain changes in the blood, which render it less fit for the purposes of life, and especially for that of evolving animal heat, a function performed in the minute vessels. Now the reparation of these changes is the proper office of the lungs, which is accomplished by the latter circuit.

Physiologists have accordingly divided the circulation into systemic and pulmonic, both performed at the same time by different sets of vessels, but by the same heart, in virtue of the structure already mentioned, and in the following manner:

The blood vessels, which are hollow tubes possessing a contractile power, proceed from the heart by two large trunks, one called the aorta, and the other the pulmonic artery. The aorta ascends perpendicularly for a short distance towards the top of the chest, and then bends down backwards, forming what is termed the arch of the aorta, from which several branches are sent off to the head and upper extremities; then proceeding downwards in the direction of the spine, it goes to the lower extremities, and

sends off branches to every part of the body. After being thus dispersed over the system, the blood is again collected by another set of vessels, termed veins, formed by the recombination of a number of minuter, into larger branches, all finally terminating in two large veins, called superior and inferior cava, which pour their contents back into the heart. The arteries carrying the blood, and the veins returning with it, generally, in their course, accompany each other.

The other trunk, called the pulmonary artery, proceeds to the lungs alone, and divides first into two branches, one going to the right and the other to the left, and then into an infinite multitude of smaller vessels dispersed through the lungs, an organ to be described hereafter. The blood is here again collected by veins, and finally returned to the heart by four large branches, called pulmonary veins.

Now the blood returning from the various parts of the body, is poured by the two venæ cavæ into the right auricle of the heart, and that returning from the lungs by the pulmonary veins, is at the same instant poured into the left; and the two auricles contracting together, propel forward their contents to their respective ventricles. The ventricles

being now excited to action, their simultaneous contraction propels their contents at the same instant to the lungs and to the system at large, its return into the auricles being prevented by valves placed at the mouth of each ventricle. The right ventricle which, through its auricle, receives the blood returning from the body at large, impels it on through the pulmonary artery to be restored to a suitable condition for the vital purposes; and the left ventricle, which receives the blood through its auricle from the lungs, sends it forwards to the aorta to be carried to all parts of the body: the left ventricle having the larger task to perform, is considerably stronger than the right. But the circulation is not carried on by the force of the heart alone, every artery, from the largest to the smallest branch, being furnished with fibres which have some degree of contractile power; and their range of action or mobility gradually decreasing as they become smaller and smaller, tends to equalize the flow of the blood, and causes it to return by the veins without intermission or pulsation.

The mouths of the arteries, where they receive their blood from the heart, are also furnished with valves to prevent its return into the ventricles; and the veins which

bring back the blood to the heart are abundantly supplied with valves, formed by detached portions of their membrane, stretching obliquely across them, which become extended when pressed upon by the blood, and prevent it from causing congestion in the lower extremities by supporting the weight of the incumbent column.

The pulsation of the arteries is generally ascribed to their distension, produced by the blood driven into them; but the beating of the heart is not referred to the distension of that organ, being explained in the following manner:

When the heart contracts upon the blood within, the distended arch of the aorta is supposed to become elongated, or to have a tendency to assume the rectilinear position, and thus, by throwing the apex of the heart against the ribs, to produce the beating in question. The subject is, however, by no means devoid of difficulty.

Circulation is the chief function of organic life, and may derive its powers of action, principally from the gangliac system. But the heart is also supplied with nerves from the brain; and anatomy exhibits, in various parts, cerebral nerves, ramified over the contiguous vessels; and thus it appears doubtful,

whether the brain does not also contribute to organic functions. This is, however, still less dubious in the function next to be considered, which is respiration.

## RESPIRATION.

The blood going to the lungs is of a black colour; that returning from them of a bright red; the air that enters the lungs is different also in chemical properties from that expelled out of them. Now in whatever manner these changes, which experience shews to be essential to life, are effected, their accomplishment requires that the venous blood and air should be brought into, and for a short time retained, in the nearest possible state of proximity over an extensive surface; and this it is the business of the peculiar mechanism of the lungs to perform.

Their external appearance it were useless to describe, as no verbal description can convey a distinct idea of a viscus that bears no resemblance to any other object.

They occupy nearly the whole cavity of the thorax, almost surrounding the heart. They are divided into right and left, the one having no direct communication with the

other; the trachea, or wind-pipe, which supplies them with air, and the artery with blood, both dividing into distinct branches, ramified through each. Their internal structure should be distinctly understood, as it enables us to conceive how the blood and air are brought into proximity.

The lungs, which are of a spongy texture, are almost wholly composed of air-vessels and blood-vessels, intimately blended together, a thin membrane alone being interposed between them, which does not prevent the necessary changes from being effected.

The air is admitted through the trachea, dividing into branches, which take the name of bronchi, becoming like arteries successively more and more minute, but still retaining their elastic cartilaginous structure. These finally terminate in small vesicles, or air cells, scarcely large enough to be visible, having all free communication together. Over these cells, the aggregate surface of which is calculated to exceed that of the rest of the body, the minute branches of the pulmonary artery are ramified; and thus, when the lungs are distended, the air and the black blood are brought into close proximity. Besides the bronchi and blood-vessels, the lungs are composed of common cellular membrane, which

forms the basis of their structure, uniting all parts together into an aggregated mass; and they are supplied, besides, with nerves in common with every other organ, and a separate class of minute vessels, subservient to their nourishment, and the renovation of their substance.

From considering the internal mechanism of the lungs, we may now turn our attention to that by which respiration is performed, consisting in the alternate admission of air into, and its expulsion out of the lungs.

The cavity of the thorax is surrounded by the ribs, branching off from the spine, and meeting before at the sternum, forming the shape of an irregular truncated cone. This cavity is completed at its base by a broad flat tendinous muscle, called the diaphragm, or midrif, which expands across from the margin of the lower ribs on one side to those of the other, presenting a surface convex above towards the chest, and concave below towards the abdomen, completely dividing the one from the other.

The whole cavity of the chest is lined internally with a compact membrane attached outwardly to the sides of the ribs, and presenting a smooth surface inwardly, which is continually lubricated by a fluid exhaled

from it, or a vapour which condenses into fluid. This membrane, after spreading over the whole surface of the chest, meets in the centre, and forms a partition, termed mediastinum, between the right and the left lung; thus separating into two distinct impervious bags, called pleuræ, between the folds of which the heart is situated. The lungs thus contained in the cavity of the thorax, rendered impervious by the pleura, which covers the whole surface, and closely envelopes every vessel that passes through it, are again invested in a second fold of the same membrane, which is reflected back over them, and closely adheres to the whole of their external surface; so that notwithstanding the thorax is perforated by several vessels, the pleuræ still remain impervious, forming on each side a two-fold bag, lining the cavity, and enveloping the organ contained in it. This circumstance is essential to the explanation of the function of respiration, which is accomplished by the alternate expansion, and contraction of the thorax.

The air is thereby alternately sucked into, and expelled out of the lungs, as in the familiar instance of a pair of bellows; for though not attached to the sides of the chest, they expand with it, owing to the pleuræ

being impervious; the external pressure of the atmosphere causing the air to rush into, and distend the lungs, on principles that may easily be understood by such as are acquainted with the doctrine of pneumatics.

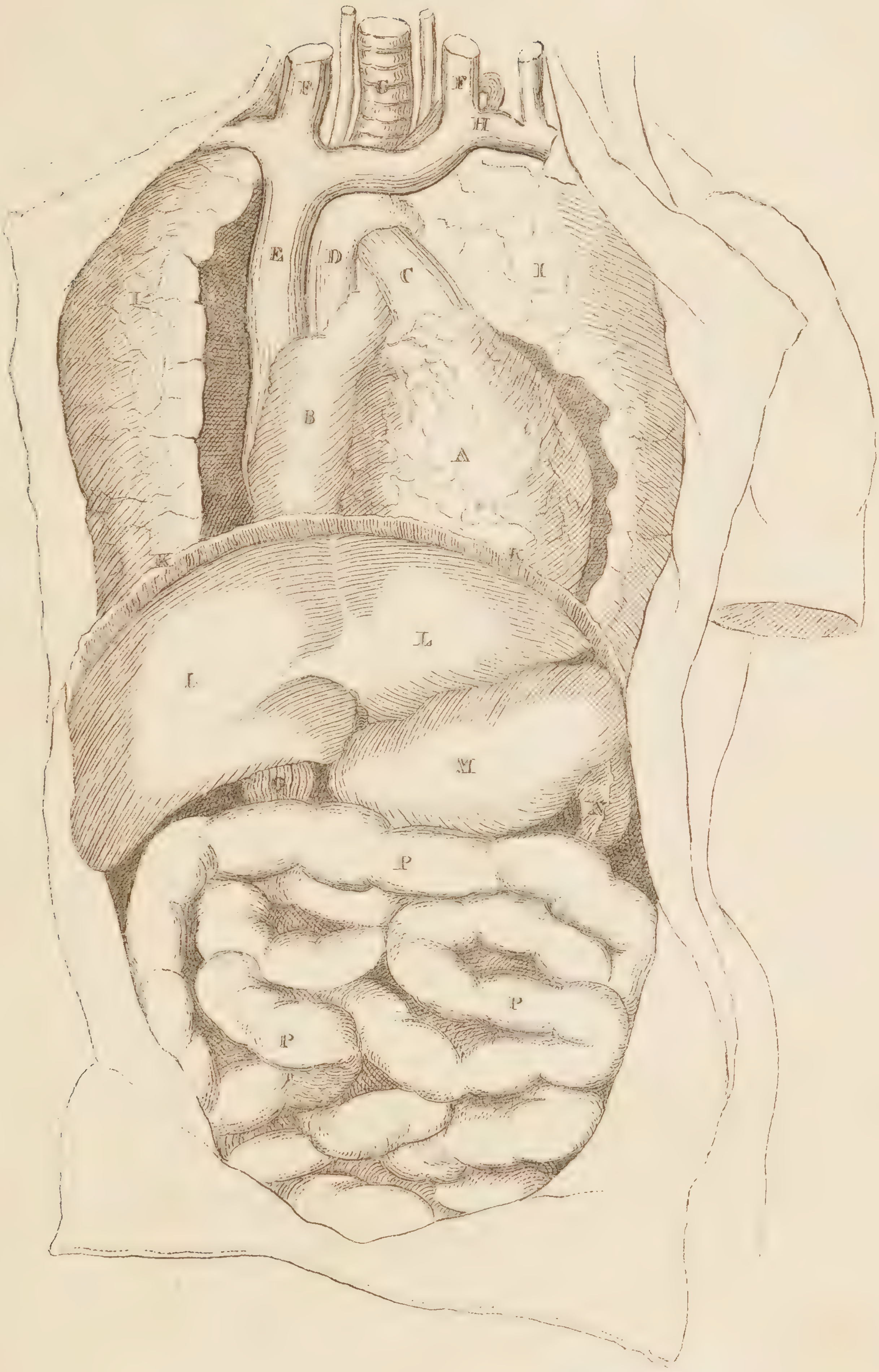
The enlargement of the capacity of the thorax is performed by the elevation of the ribs, and the depression of the diaphragm; the latter increasing its length, and the former, from their relative position, as before described, enlarging its width; and this constitutes inspiration. Expiration is accomplished by the spontaneous return of the ribs to their natural position, and by the resistance of the abdominal viscera, compressed by the descent of the diaphragm, now forcing it back again; thus reducing the capacity of the thorax, and expelling the superfluous portion of the air.

Respiration being one of the most important of organic functions, the suspension of which cannot be supported for many moments without fatal effects, we should expect to find it dependant upon the gangliac system; but on the contrary, both the intercostal muscles, and the diaphragm, derive their nerves chiefly from the cerebral system; are manifestly subject to its influence and controul, and their action, unlike that of the heart and

intestines, is instantly suspended when the sensorium is removed.

The cause that excites the sensorium, or cerebral system, to produce an effort of inspiration, is supposed to be the uneasy sensation produced by congestion of blood in the lungs, which may be readily perceived by voluntarily suspending the breath, but does not in general excite attention in the mind, shewing that animal, as well as organic life, may perceive, and correspond to impressions, without being mentally conscious of their existence.

Were we to follow the order in which the functions are performed, perhaps digestion should have preceded circulation and respiration; but the more complicated functions cannot be explained without a previous acquaintance with those which are more simple. Respiration and circulation may be understood without a knowledge of digestion; but digestion involves secretion, and secretion presupposes circulation;—circulation, again, is essentially connected with respiration, and thus the natural order appears by no means the most expedient as an order for description.




Etched by S. Yates, Lpool.

# SECRETION.

Secretion is the process by which the different fluids of the living body are formed. As most of them are produced out of the blood impelled by the heart and arteries through a series of minute vessels, or organs of a peculiar structure called glands, which vary in form and appearance as much as the fluids themselves, it appears probable that this function depends upon the joint influence of filtration, separating the original fluid into its more simple constituents, and of subsequent recombination of these elements in different proportions, so as to form new results, according to the peculiar arrangement of vessels in each secreting organ. As cutting the nerves leading to a secreting organ affects the secretion, some have concluded that the nervous influence also contributes to promote the decomposition and recombination effected; but this change is sufficiently accounted for, by the altered tone of the secreting vessels that results from such an operation.

Secretion is performed either by membranes or glands, two classes of organs which

it is of the first importance to the physiological enquirer to consider attentively.

Membranes are not to be regarded as mere coverings to envelope different organs, but frequently as the most important part of the organ itself: thus, as already shewn, the mucous membranes of the nose and tongue are the seat of the senses of smell and taste; and a continuation of the same membrane, covering the stomach and intestines, will hereafter be seen to perform the most important part of the function of digestion.

The secreting membranes have been distinguished into serous and mucous, characterised by the following differences:

The external form of serous membranes is every where the same; they constitute a double covering to all the viscera, one fold of which envelopes the organ itself, and the other lines the cavity that contains it, after the manner of the pleura already described, the two together forming an impervious bag, redoubled upon itself. The two inner surfaces meeting together, allow free motion upon each other, both from their natural smoothness, and from a fluid, or vapour that condenses into fluid, continually exhaled from and absorbed by the membrane.

These membranes are each separate, and

form so many distinct bags, having no communication together but through the medium of intervening vessels; hence one is often diseased, without participation of others.

To this class belong some already noticed, as the pleura covering the lungs, the pia mater and arachnoid coat of the brain, and the sinovial membrane lubricating the joints.

The internal structure of serous membranes is stated by Bichât to consist of a tissue of minute vessels, connected together by cellular membrane. These vessels are of two classes, one of which, called exhalent, continually supplies a thin serous fluid or vapour, derived directly from the blood; and the other class, termed absorbent, constantly takes it up again, and conveys it back into the blood.

The external form of mucous membranes is simple, but their internal structure more complex; they serve in general to cover the internal, as serous membranes do the external surface of organs: but this is the least important office they perform. They constitute the organ of feeling in such as are capable of exciting mental perception, as the nose and the mouth, their peculiar structure modifying the impression received by the nerves; and in organs not capable of exciting attention in

the mind, as in the stomach and intestines, they appear to perform a function perfectly analogous, though not productive of mental perception, causing these organs to yield to impressions that are grateful, and resist such as are painful: the fluid secreted by them serves, moreover, to lubricate and protect their surface. Of this class some have been also noticed already, as the membrane of the nose and mouth, the conjunctiva of the eye, the inner surface of the larynx;—and a continuation of the same membrane descends down the trachea into the lungs. The whole intestinal canal, as will be seen hereafter, is lined with a similar covering, from the throat to the rectum.

The internal structure of mucous membranes appears to consist of the following parts:—The basis of its fabric is formed of cellular membrane, which connects all parts together; its surface is covered over with numerous papillæ, more or less distinct, in different parts; those of the tongue have been already noticed, which give it a velvet-like appearance, and are usually regarded as a peculiar structure of the sentient extremities of nerves, modifying in a particular manner the impressions received by them. They are covered externally by a thin soft membrane,

called epidermis, or cuticle, which is thicker where they are exposed to the air, and serves to protect them from injury by too strong an impression. Ramified under the surface of mucous membranes is a tissue or network of small red vessels, which give them the colour that characterises them, and contribute to their sensibility. Imbedded in the cellular membrane beneath, an infinite number of minute follicles, or glands, are seated, which secrete the mucous fluid, and pour it out by small excretory ducts upon the surface. Besides these they are also abundantly supplied with exhalents and absorbents, like those of the serous membrane.

When a mucous membrane remains exposed to the air, and to external impressions, its cuticle becomes thicker, and it at length assumes the appearance of skin; and the skin of the fœtus, in the earlier months of pregnancy, has the appearance of mucous membrane. The skin is also composed of similar parts, namely, cellular membrane as its basis, cuticle, or epidermis, tissue of vessels beneath, glands, in some parts very abundant, exhalents, and absorbents. There is, moreover, under the cuticle of the skin, an additional substance called rete mucosum, which appears like indurated mucus, white in the

European, but dark in the African. The closest affinity appears then to subsist between the external and internal covering of the body, in structure as well as function.

A similar resemblance may also be traced between the serous and cellular membranes. The serous membranes cover the different viscera, and lubricate their surface to facilitate motion: the cellular membrane covers each muscle, and every separate muscular fibre, exhaling a vapour or thin fluid for the same purpose. Both are supposed to consist chiefly of a tissue of minute vessels, and both exhibit by analysis a cellular structure; serous being regarded as more condensed cellular membrane. The chief difference consists in the external form, the one constituting an impervious bag, the other a general covering, the cells of which communicate freely together in all parts of the body; and hence, in affections of the cellular membrane, all participate, as when too great an accumulation of the exhaled fluid takes place in general dropsy.

Glands are situated in different parts of the body, and vary as much in their structure and appearance as the fluids they secrete. They are generally of an irregular lobular form, and of every size, from the smallest

visible point to that of the liver, the largest gland in the body. The internal structure of the small globular bodies found in them, is variously described by different anatomists. Some suppose them to be a mere convolution of vessels terminating in an excretory duct; others, to consist of a hollow cavity, or follicle, with minute vessels leading into and out of it. In some of the larger glands a number of these follicles are found with each a separate vessel, a number of which unite together, like veins, into one branch, forming an excretory duct.

As it is not probable that the particular structure of these organs will ever be sufficiently developed to enable us to account for the peculiar properties of each secreted fluid, their minute differences are of less importance than the general fact, that the formation of a different fluid is attended with, or results from a different structure in the secreting organ.

The secretions subservient to the function of digestion are saliva, gastric fluid, bile, pancreatic juice, serum, and mucus.

Saliva is formed by five glands, one called parotid, near the hollow of each cheek; one called sub-maxillary, under the edge of the lower jaw on each side; and another

under the tongue, called sublingual. Their excretory ducts open into the mouth on each side of the cheek, and from under the tongue.

The gastric fluid, the miraculous properties of which have been variously described by experimenters, who are too frequently disposed to amuse their readers by magnifying the wonders they discover, seems to consist chiefly of the serous secretion from the surface of the stomach, mixed with the residuum of the food remaining in that organ; which appears from experiments by Carminiati, to form at the usual temperature of the body, one of the most powerful solvents for substances of a similar nature, whether animal or vegetable. As the food is continually varying, so are the properties of this fluid, and the powers of digestion; sudden changes of diet being liable to promote indigestion, while habit, as Spallanzani shews, may teach a sheep to live upon animal, and an eagle on vegetable diet; after which a sudden return to their natural food is again attended with inconvenience.

The pancreatic juice, as it is named, nearly resembles saliva in appearance and chemical properties, and is also secreted by a gland, situated in the superior part of the abdomen, immediately behind the stomach. Its inter-

nal structure also corresponds with that of the salivary glands, being composed of small globular bodies, consisting either of a congeries of minute vessels, or of follicles, with vessels leading to them. These ducts all unite finally into one larger branch, which pours out its contents into the intestines, a little below the inferior orifice of the stomach, to mix with the residuum of food passing out of that organ.

The bile is a fluid of a yellowish colour, approaching more or less to green, according to its degree of inspissation: it is rather viscid, and extremely bitter. It is secreted by a very large gland, situated directly under the diaphragm, and over the stomach and other abdominal viscera, inclining more to the right than the left side. Its surface is convex above, corresponding to the concave surface of the diaphragm, to which it is attached by a membranous ligament extending across its middle from the anterior to the posterior edge. The under surface of the liver is more flat, and its edges, which form an angle more acute before, and more obtuse behind, are also attached by different ligaments to the adjoining parietes of the abdomen, but allow it to ascend and descend with the diaphragm in the act of respiration.

The internal structure of the liver exhibits innumerable ramifications of vessels, one remarkable peculiarity characterising its circulation, which is, that the blood from which its secretion proceeds, is derived from the venous, and not the arterial system. The blood returning upwards from all the abdominal viscera, except the kidneys, is collected into one large vessel, called the vena portæ, which enters the liver at its under surface, and then, contrary to other veins, divides into numerous branches throughout the substance of this organ, from which the bile is secreted. These minute branches lead to what are termed the pori biliarii, that junction taking place in small corpuscles, about the structure of which anatomists are not agreed, some regarding them as cryptæ, or follicles, others as convolutions of vessels. From these, two sets of vessels arise, each uniting successively in larger and larger branches until they terminate; one class in the biliary duct, that carries the bile into the intestines; and the other in the venæ cavæ hepaticæ, which carry the remaining blood forward by two or three large trunks to the vena cava.

The liver is also supplied with arterial blood from the hepatic artery, for the pur-

poses of nutrition, the extreme branches of which also terminate in the venæ hepaticæ.

When the bile is not required for the purposes of digestion, it is carried into a small bag of a pyriform shape, attached to the under surface of the liver, and nearly in contact with the stomach at the lower orifice. This bag communicates by a small canal, called the cystic duct, with the duct proceeding from the liver to the intestines, which is called ductus hepaticus, the part below the junction taking the name of ductus choledochus communis. When the passage through the common duct into the intestines is closed or obstructed, the bile flows back into the gall bladder, and fills it; but when the common duct relaxes, the contents flow out by the cystic duct, and proceed along with that coming from the hepatic duct into the intestines, to contribute to the function of digestion.

## DIGESTION.

Digestion is that process which prepares the food for conversion into the living solid, performed during its transmission through the stomach and intestines, from whence the

newly-assimilated fluid is absorbed and carried into the blood, the residuum being propelled forwards and excreted or thrown off.

The first part of the process of assimilation is mastication, an office belonging to the mouth, which discriminates those substances that are, from those that are not suitable for the purpose of nutrition; and after bruising the food received into a soft pulpy mass, and mixing it intimately with the saliva, transmits it as soon as perfectly assimilated to the organ of taste, to be carried forwards by deglutition.

Deglutition is performed by a tube leading down behind the trachea to the stomach, which is distinguished into two parts, the superior termed pharynx, and the inferior œsophagus. The pharynx is the mouth or entrance of the œsophagus, and consists of a muscular bag shaped like an irregular funnel, occupying the back part of the fauces, with its anterior edge connected to the larynx.

In deglutition the food is first propelled backwards by the tongue, the larynx is then drawn upwards and forwards by the different muscles belonging to it; by which means the epiglottis is more firmly closed, and the food prevented from getting into the larynx, being at the same time forced

over it, and the mouth of the pharynx widened to receive it. As soon as the food has passed what is termed the isthmus faucium, the larynx resumes its former position, and thus assists in propelling it downwards into the œsophagus, by which it is transmitted to the stomach.

The œsophagus is a fleshy canal running down in the direction of the spine, terminating, after it has passed the diaphragm on the left side, in the superior part of the larger extremity of the stomach, where it takes the name of cardia. This canal is composed of two layers of muscular fibres, connected by cellular membrane, one of which is longitudinal and external, the other circular and internal, These muscular fibres, which are covered externally by a serous, and internally by a mucous membrane, by their joint efforts of contraction, propel the food into the stomach.

More complete mixture and assimilation is performed in the stomach, and a large portion of the food is absorbed or taken up, and carried into the blood by a multitude of minute vessels opening from its surface, which will be more particularly described hereafter.

The stomach is a large membranous bag, stretching across the abdomen from the left to the right side, where it is covered by the liver. The portion situated to the left below the œsophagus, called the cardiac portion, is the most capacious, and gradually contracts towards the other extremity, which terminates in a small orifice, called pylorus, from whence this is termed the pyloric portion. The stomach, like the œsophagus, is composed of serous membrane externally, mucous internally, with cellular membrane and muscular fibres between. By the gradual contraction of these fibres, it accommodates its capacity to its contents, and propels the food that remains after absorption through the pylorus to the intestines. These fibres perform also another species of action, called the peristaltic motion, which consists in the successive contraction of the circular fibres, producing an appearance something like that exhibited by the motions of a worm; but this resemblance is more obvious in the intestines than the stomach, and is hence sometimes named the vermicular motion. As the stomach is placed in a great measure under the liver, it is subjected to some degree of pressure by every descent of the diaphragm, which may

contribute along with its peristaltic motion to the more perfect mixture and maceration of its contents.

Besides the absorbent vessels, which are continually taking away the more fluid parts of the ingesta, another class are constantly pouring out fresh fluid, which keeps up the process of assimilation; and this continual change of substance probably contributes to prevent fermentation, one of the wonderful properties ascribed solely to the gastric juice. A slight degree of it however takes place, and if the food be imperfectly masticated and dissolved in the saliva, so as to retard the process of assimilation and absorption, it is liable to increase to an unusual degree, and air is copiously evolved, causing eructations and painful distension. Suppressed secretion from the surface of the stomach diminishing the supply of fresh fluids suitable for assimilation, may also produce the same effect, and is probably a frequent cause of fermentation, as indigestion is usually attended with thirst and a dry tongue, symptoms of impaired secretion.

When the stomach is distended with food, the lower orifice closes, and its escape is prevented before assimilation and absorption have been performed. What remains in the

stomach when the pylorus relaxes, is somewhat diminished in quantity, and completely changed in quality, and requires a different process to render it fit for the purposes of nutrition, which it undergoes in passing thro' the pylorus into the intestines; but the more fluid portion previously absorbed cannot be regarded as imperfectly prepared for absorption, an opinion apparently entertained by some physiologists, or means would have been provided to prevent such an effect.

Immediately below the pylorus, (a strong muscular ring, possessing sufficient contractile power to retain the contents of the stomach,) the intestines commence, which form a continued canal, about thirty feet long, folded into numerous convolutions, all attached at their posterior edge to the spine by means of a membrane, which surrounds and retains them in their proper situation. From differences in the structure, and arrangement of the parts composing this canal, it is divided into small and large intestines, and these are again subdivided, each into three parts.

The small intestines, which constitute the superior portion, consist of the duodenum, the jejunum, and the ileum, and exhibit no remarkable variety of structure.

The large intestines occupy the lower

extremity, and consist of the cœcum, the colon and rectum, which are wider, stronger, and form fewer convolutions than the small intestines.

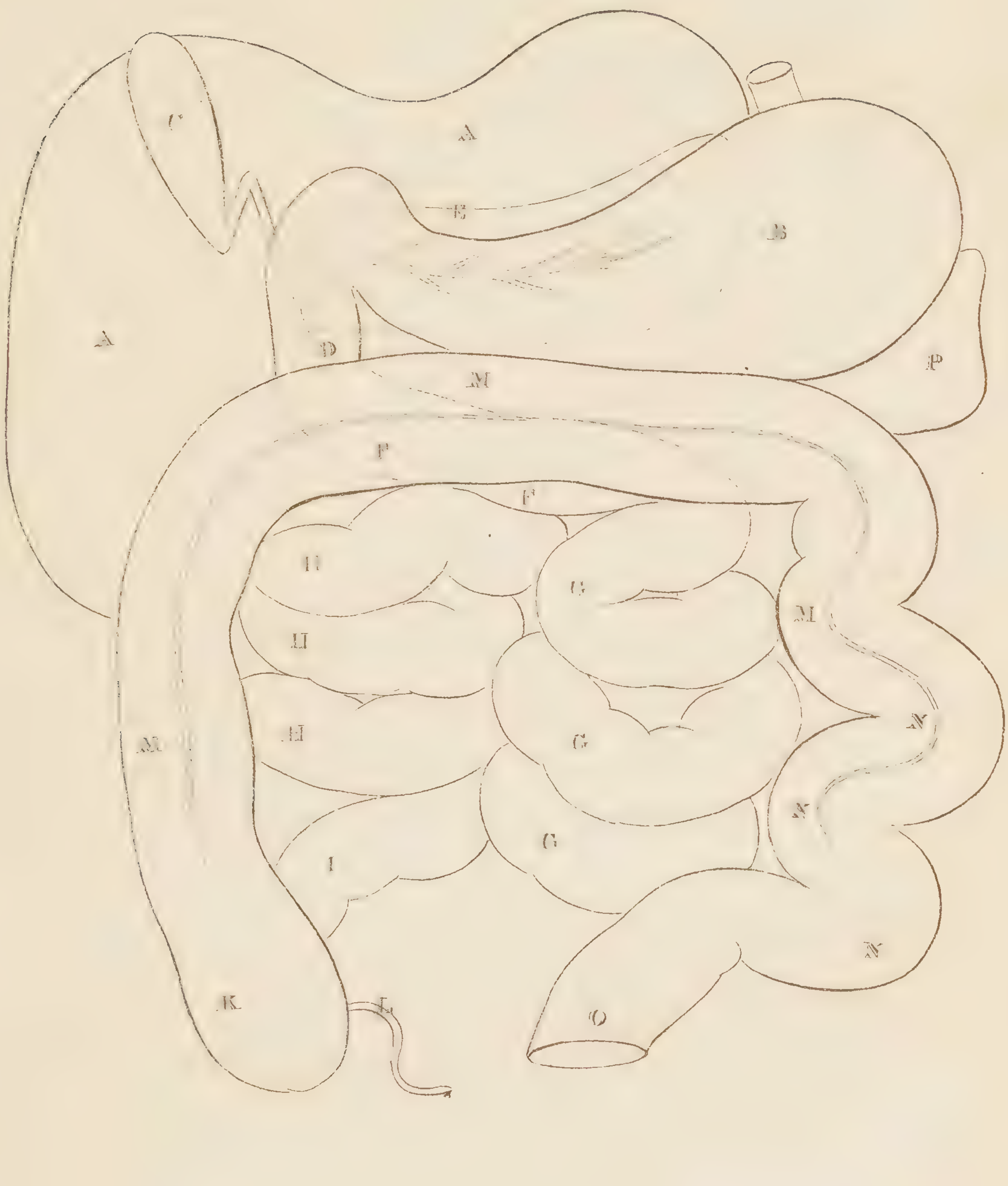
The cœcum is a short round bag, or cul de sac, two or three inches long, situated below the ribs on the right side, commencing at the termination of the ileum, which opens into it by a kind of valve, that prevents the ingesta, once past, from returning. The bottom of the cœcum has a small membranous tube attached to it, resembling a worm in appearance, and hence called the vermicular process, the use of which is not known.

The colon is the longest of the large intestines, and contains the ingesta, now become fœculent, until they are voided by the rectum. The colon begins at the right side from the cœcum, ascends a little way, and crosses over in front of the small intestines and immediately below the stomach, then descending on the left side, it forms a double flexure, called sigmoid, from its resemblance to the Greek ς, and terminates in the rectum.

The rectum is a short straight gut, provided at its extremity with a strong muscular ring, called its sphincter, which performs a similar office to the pylorus, retaining the

contents of the organ, or transmitting them under suitable circumstances.

The whole of the intestinal canal is covered with a serous membrane externally, and a mucous membrane internally, with muscular fibres and cellular membrane intervening. The successive contraction of the circular fibres propels the ingesta forwards, and forms the peristaltic motion. The colon is furnished with three strong bands of fibres running longitudinally from one end to the other, which probably assist in promoting the expulsion of its contents. The fibres of the rectum are more numerous and dense than those of the other intestines, the use of which is obvious. The serous membrane enveloping the intestines is called peritoneum, which serves, after separately investing all the abdominal viscera, including the liver and pancreas, to line the cavity of the abdomen, covering the inferior surface of the diaphragm, the posterior surface of the parietes of the abdomen, and the anterior surface of the spine. After forming as many convolutions as the intestines which it surrounds, the opposite edges meeting at the spine, seem to form a single membrane, termed mesentery, where it attaches the small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intestines to the back; mesocolon where it performs the same office for the colon; and mesorectum where it attaches the rectum. It also covers the stomach, and its folds hanging loosely down from the inferior edge of that organ, form a kind of curtain, generally loaded with fat, floating in front of the small intestines, where it is called omentum, or caul. Between the folds of the mesentery and mesocolon, arteries and veins may be seen passing to and from the intestines and absorbents, which serve for the conveyance of the newly assimilated food to the rest of the system, in a manner to be described hereafter.

The residuum of food that passes out of the stomach appears to have undergone material changes during its retention in this organ: the absorption of the more fluid part has rendered fresh dilution necessary, and it appears also to have acquired a considerable degree of acidity. In passing from the stomach to the duodenum, it finds a remedy for both these changes, in mixing with the pancreatic juice and the bile, flowing from their respective ducts a few inches below the pylorus; and it now passes progressively on through the whole length of the intestinal canal, probably still exposed to the changes

produced by constant secretion and absorption. Air seems to be evolved both in the stomach and intestines; in the superior portion of the intestines from incipient fermentation, and from incipient putrescency in the inferior portion of this canal, as evinced by the fetid odour that arises. Both these gasses probably contribute to some useful purpose in the animal economy; and none appears more likely than that of keeping the intestines sufficiently distended and likewise elongated, whereby a derangement is effectually prevented, which under some circumstances is known to occur, and proves highly dangerous. This is an affection termed intus-susceptio, in which a fold of the intestine is carried on along with the ingesta accumulated within it, from some cause obstructing their transmission, and becomes involved within the portion below it, doubling one fold upon another, and thus producing inflammation. As the food passes on, it is continually losing more and more of its fluidity from absorption; but the colon is stated to be less amply supplied with absorbents, though probably it is their minuteness alone which causes them to elude detection. Absorption certainly goes on in some degree; but the vessels being very minute, may prevent the more gross matter

contained from being again carried into the circulation.

Various opinions are entertained respecting the share which the bile has in the function of digestion; whether it may serve to neutralize the chyme proceeding from the stomach; to check fermentation or putrefaction in the larger intestines; or by its irritating quality to stimulate these organs to contract. The admission of one or all of these opinions does not necessarily preclude that of another purpose, ascribed by writers of considerable celebrity to the organ that secretes it. This is the purification of the venous blood of something prejudicial to the animal economy, previous to its return to the heart. In the fœtus in utero, where bile seems unnecessary for the purposes of digestion, the blood is conveyed to the liver prior to other organs, which at this is much larger too in proportion than at any other period of life; circumstances which confirm the probability of its producing some essential change in the nature and properties of the venous blood.

Before we proceed to the consideration of absorption and excretion, another important organ claims our attention, whose function is also concerned in digestion, and this is the spleen.

This organ is somewhat of an oblong form and spongy texture, placed at the left side in contact with the larger extremity of the stomach, and enveloped, in common with the other abdominal viscera, in a peritoneal covering. It appears to consist entirely of arteries and veins, surrounded by a strong fibrous membrane, called its tunic. It derives its arterial blood from the same source as the stomach, and sends its venous blood, in common with the other abdominal viscera, to the liver. It becomes compressed, and the blood prevented from circulating so abundantly through it, when the stomach is distended, but is again filled, and resumes its office as the stomach empties.

Different opinions are entertained respecting its use; some suppose, as it sends a larger supply of venous blood than other organs to the liver, that its chief business is to prepare blood for the biliary secretion. Another use has also been assigned to it, that has a strong claim to our attention. As it derives its arterial blood from the same branch as the stomach, and is compressed as this organ enlarges, the blood which would have gone to the spleen will now be thrown more abundantly upon the vessels of the stomach, and serve to supply their increasing capacity,

and allow for the more copious secretion of gastric juice. Upon the whole, it appears that the admission of one does not preclude that of the other function; and, as the demand for the biliary secretion is partially suspended while the stomach is full and the pylorus closed, at the same time that the demand for the gastric secretion is augmented from the same circumstance; and, on the other hand, as the demand for biliary secretion augments, and that for gastric secretion diminishes when the pylorus relaxes; it seems highly probable, that the spleen may answer the purpose of increasing the afflux of arterial blood to the stomach, or of venous blood to the liver, according to the circumstances under which each of these organs most requires it, by the simple means already described.

## ABSORPTION.

The process of absorption, which consists in the transportation of different fluids from the cavities that contain them into the blood, appears to be going on from all parts of the body, by means of a separate class of vessels, exclusively destined to that purpose.

The cellular membrane surrounding the muscles, which, as its name indicates, forms innumerable cells ; the sinovial membrane, lining the cavities and covering the surface of the joints, as already stated ; the serous membranes, which in the same manner envelope the different viscera ; are all moistened by vapour or fluid poured out by exhalents and taken up by absorbents.

The absorbents are small vessels proceeding from the arteries, but too minute to admit red blood, and have nothing peculiar in their structure, except their open mouths terminating on the surface of these membranes.

The absorbents are of a peculiar structure, being furnished with innumerable valves, formed by a loose fold of membrane stretching obliquely across them, so as to become extended and close the passage if their contents be forced in a retrograde direction. These valves are in some parts so numerous, that four or five are contained within the space of an inch. The absorbents are much more frequently united together by what are called anastomosing branches, than other vessels, forming in some parts near the surface the appearance of an irregular net-work; but the most remarkable distinction that at-

tends them, is the distribution of numerous glands through their course, varying from a minute point to the size of a pistol ball. The internal structure of these glands is a point of dispute, and their use is wholly unknown. The largest are situated about the flexures of the joints, as in the region of the neck, in the axilla or arm-pit, in the groin, behind the knee, and inside the elbow.

From the internal surface of the intestines and stomach the absorbents proceed in great abundance, and passing between the folds of the mesentery and other membranes enveloping these organs, where they meet with innumerable glands in their way, convey the nutriment to the system. Those arising from the small intestines, as already stated, are found to be larger than those of the stomach and colon, and as they carry an opake white fluid, like milk, they have been distinguished by the name of lacteals, while all the rest are comprised under the common denomination of lymphatics. Whether any vessels of a similar description arise from the external as well as the internal surface is a disputed point; and to discuss the merits of the question would engross too

much time to be consistent with an elementary treatise.

Now a large portion of the lymphatics and the whole of the lacteals, as far as they have been hitherto discovered, appear to collect together from all parts of the body into one common trunk, called the thoracic duct, which pours its contents into the angle formed by two large veins called the internal jugular and subclavian of the left side, nearly opposite to the sixth vertebra of the neck. The remainder of the lymphatics form another common trunk, which in a similar manner pours its contents into the blood generally on the opposite side. The contents of these trunks becoming mixed with the general mass of blood, soon cease to be discernible, and proceeding with it to the heart, the whole is sent forward to the lungs, where the mixture is completed, and as is generally supposed the process of assimilation terminated.

As the absorbents have no pulsation, it has been considered a difficult point to ascertain how the fluid is propelled along them, and still more how it gains admission into them : and a late writer of considerable celebrity thought it necessary to frame

a particular hypothesis, in order to get over the difficulty. He ascribed to the mouths of these vessels a peculiar power, different from any thing else in the animal economy, by means of which they were enabled to suck up a fluid or corrode and eat away a solid substance like bone.

As all the contents of vessels are in a fluid state, we may safely assume, that solution precedes absorption; and in the subsequent enquiry we shall consider how it is acomplished. The remaining difficulties will probably vanish, if we consider, that pressure alone is sufficient to cause the admission of fluids into their open mouths; and their transmission will follow from the same cause, in virtue of the valvular structure already explained.

Now all parts of the absorbent system are subjected to occasional or continual pressure; the cellular membrane from the action of muscles; the sinovial from that of the joints; the serous membranes of the thorax and abdomen from the action of the diaphragm, alternately compressing all the abdominal and thoracic viscera; the lacteals from the same cause, and more particularly, as stated by Haller, from the peristaltic motion of the intestines. But what, it may be asked, can cause pressure in the internal

cavities of bone, so as to force the fluid from the cells containing it? Nor is the difficulty at all formidable here. If the cavity be full, the vis a tergo, or the pressure of fresh fluid entering into it, will force out that contained. If it be only partially full, or nearly empty, elastic vapour will necessarily exist in it, and this will have the same effect, on the principle of the common forcing pump.

In confirmation of the opinion, that pressure contributes to the assumption and propulsion of the fluids absorbed, the acknowledged efficacy of friction may be alleged in promoting this process; to which may be added, the peculiar situation in which the larger glands are placed, necessarily exposing them to some degree of pressure from the motions of the body; and lastly the obvious expediency of valvular structure in causing this effect to result from pressure, as the contents being unable to return must consequently be propelled forward. To this cause of propulsion we may also add the gradual re-action of the vessels themselves, which no doubt possess a certain degree of contractile power, when sufficiently distended.

## EXCRETION.

Excretion is the last function that remains to be considered. As the whole substance of the body is continually renewing, fresh particles being assimilated, while others are detached and thrown off, the means by which this is accomplished now claim our attention. The channels through which the excrementitious particles are finally thrown off are the internal and external surfaces; thus the skin, the lungs, the urinary bladder, and the intestines obviously perform this function. The question then suggests itself, how are these particles conveyed to the surfaces? At first we might be led from analogy to expect a distinct class of vessels collecting excrementitious matter from all parts, and pouring their contents, like the absorbents, into a single duct to be carried away from the body. But the singular fact is, that these very absorbents themselves are the instruments by which the excrementitious particles are removed; the materials which are supposed to be no longer fit for the purposes of life being again taken up by them, carried to the tho-

racic duct, there mixed with the chyle from the intestines, and all poured together into the common mass of the blood. It is from the blood then that the excrementitious particles detached and dissolved must be directly derived, and this is accomplished by numerous vessels opening upon the internal and external surface of the body; the lungs also contribute to the same function; and the kidneys, which will be noticed afterwards, have likewise a conspicuous share in this process.

It is probable that a very considerable portion of the fœculent matter voided from the intestines may consist of the residuum of food which has never entered the blood; but as the whole solid mass of the body is continually changing, an emunctory adequate to this effect is required; and the excretion from the mouths of vessels terminating in the intestinal canal, presents the most obvious source, from which the more solid parts of the excretions are derived; while the skin, the lungs, and the kidneys, may account for the removal of such as are of a more fluid nature.

All our nutriment when received into the body is in a state of solution, and all the solids must return to a state of solution before

they are excreted; its transition, first into the living solid, and lastly into a state of comparative solidity when excreted, are only parallel phenomena; the latter being certainly the more easy of the two to be accounted for, as shewn by what has been already suggested in noticing the process of absorption continually carrying off the more fluid contents of the intestines.

The matter thrown off from the lungs and from the external surface of the body may be immediately separated from it; but the continual absorption from the internal surface naturally suggests the inquiry, whether the particles deposited in the alimentary canal may not again undergo a fresh process of assimilation, experiencing the same changes they had passed through before, and be repeatedly subjected to the purposes of nutrition before they are finally thrown off. The length of time that some persons have lived without taking food gives countenance to this supposition; and there are other considerations which, if insufficient to warrant its admission, are at least sufficient to dissuade us from hastily rejecting it. It must be admitted that the terms solid and fluid, as applied to the matters excreted from the body, are only relative, and we have sufficient proof of the

more fluid portions being constantly re-absorbed, if their excretion be delayed; thus the fœces become more solid, and the urine more highly coloured, by retention.

The more fluid parts of the blood are continually separated and strained off by the kidneys, two glandular organs situated in the abdomen, one on each side of the lumbar portion of the spine; they are surrounded by a fibrous capsule, and their form is too well known to require description; their internal structure is curious and interesting, as it exhibits on a larger scale what probably eludes discovery from its minuteness in small glands, namely, a very peculiar distribution of tubes, cavities, and vesicles. The kidneys derive their blood from two considerable arteries, branching off from the aorta; which, after dividing into numerous small vessels ramified through their substance, unite again into small globular bodies towards the surface in what is called the cortical substance of the kidney, the inner portion being denominated medullary, which is of a redder colour. From these globules or corpuscles, which appear to be a congeries of vessels, a number of small tubes arise, which unite and become larger, running in a radiated manner from the circumference towards the centre. These tubes,

termed tubuli uriniferi, terminate in papillæ of a conical form, at the points of which the termination of the uriniferous tubes may be seen distilling the urine into as many small funnels, or infundibula. These infundibula unite and become larger, at length forming what is called the basin, or pelvis, of the kidney, shaped like an inverted cone.

The pelvis, placed partly within and partly without the substance of the kidney, contracts into a tube, called ureter, something less than a crow-quill, which conveys the urine into the bladder.

The veins of the kidney arise from the extremities of the arteries, and carry the blood back into circulation, terminating in the vena cava.

The bladder is a membranous bag, lying at the fore part and bottom of the pelvis, composed of cellular membrane with muscular fibres, lined with mucous membrane internally, and covered with a serous membrane from the peritoneum externally.

The neck is furnished with a circular muscle, called its sphincter, which has contractile power to retain its contents, but allows their transmission when the organ is gradually compressed by a voluntary effort.

A few general observations may now conclude what must certainly be deemed a very succinct and compendious, though, it is hoped, not by any means a superficial view of the economy of the functions subservient to organic life, at least of such as are essential to the subsequent inquiry.

According to Bichât, they are characterised by their dependence upon the gangliac, and not upon the cerebral system;—by the want of symmetry of form, or two-fold structure;—by their exemption from the controul of the will;—by their spontaneous action, and the absence of mental perception from the feelings they experience;—by their continued exertion, without weariness or relaxation;—and chiefly by their relation to the internal economy of man, and not to the external objects around him. But all these distinctions, as before alleged, are true only to a certain extent.

Thus we have seen, that the effort of respiration depends entirely upon the sensorium, and circulation in voluntary organs

appears to be in part dependent upon cerebral nerves. Nutrition cannot commence, nor is excretion completed, without efforts of volition. The two-fold structure of the organs appears in the lungs and kidneys with almost as much symmetry, as in the organs of animal life. As organic functions are performed without the intervention of the will, so it may be said are many animal functions continually accomplished without any conscious effort of volition : thus, the habitual exertion of the voluntary muscles required to keep the head erect, the body poised, the eye-lids raised, the lower jaw suspended, and many others, are inconsciously performed. And even the primary organ of animal life, the brain itself, in its grand function of association of ideas, is more frequently an involuntary than a voluntary organ. As impressions made on the organs of animal life excite consciousness in the mind, so also do unusual impressions on those of organic life : thus the changes that give rise to hunger, thirst, and the accumulation of feces, excite attention, and altered circulation producing inflammation, has this effect in all parts. If habitual impressions on the involuntary organs excite no consciousness in the mind, neither do they in vo-

luntary organs: thus no sensible impression is felt from the clothes we wear; the ticking of a clock that is constantly in the room, is unnoticed; and substances which have the strongest flavor cease to produce this effect, if held long enough in the mouth. Although organic functions are performed without any suspension, we shall hereafter find, that they also, though not in an equal degree, require and receive the renovation of power derived from rest.

The best marked line of distinction is certainly drawn from the relation which the different classes bear to external or internal objects. Thus the organic functions regard only the nourishment and support of the system; the animal functions regard man's connexion with the objects around him, and "render him an inhabitant of the world at large, and not like the vegetable, of the spot which gave him birth."

Through the medium of mental association he takes cognizance of all around him; feels and thinks, experiencing the various emotions of fear, anger, ambition, hatred, revenge, which are purely animal, as they distinguish man from mere organized matter, but have nothing to do with growth and assimilation, obstructing rather than

promoting, the performance of these functions. This is an important difference. But who can suppress his astonishment, when he finds the ingenious author of this distinction, with an inconsistency singularly unfortunate, relinquish this point, by ascribing the passions and all that relates to them, wholly to organic life!

We may here close with repeating what was suggested at the beginning, that this distinction, laid down as an essential difference in the nature and attributes of the organs, is liable to innumerable objections; but adopted as a scientific classification, in which that rigid accuracy is not required, considerable advantage may be derived from it, since it serves to enlarge our views by generalization, and to assist the memory by systematic arrangement.

There is yet a third class of functions, which belong to the propagation of the species; but these being wholly unconnected with the subsequent inquiry, and the organs subservient to this purpose not being directly essential to life, their introduction was deemed unnecessary in a work that is not offered as a complete system of physiology, but rather as a foundation for one, should the principles deduced be deemed sufficiently stable to support a superstructure.

[illegible]

AN

# INQUIRY

INTO

# THE LAWS OF LIFE,

*&c. &c.*

## OBSERVATIONS

# Introductory to the Inquiry.

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STATE of the Science.——Object of the Inquiry.——Practical Use of Physiology.——Obstacles that retard its advancement.——A competent Knowledge of Anatomy essential to Physiological Inquiry.——Importance of the Capillary System. Its Limits defined.——Plan of the Inquiry, and the Mode of Investigation pursued.

THE investigation of the laws of animal life has, of late, by no means engrossed that share of attention to which it is justly entitled, although the individual efforts made since the time of Whytt and Haller, to enlarge our views of the animal economy, have been neither few nor inconsiderable.

The present state of the science of physiology may be in some measure appreciated,

from the reproof which is frequently urged against the medical reasoner by the empirical school, (comprising no small number of graduated physicians)—that he is unable satisfactorily to explain the performance of a single function, the phenomena of a single disease, or the operation of a single remedy.

However humiliating the admission of such an assertion may be, its truth cannot be wholly denied. Fully to account for the performance of one function, would be nearly paramount to the explanation of them all, for all are governed by the same general laws, and subject to the influence of similar causes; the reader must not therefore indulge the expectation of this reproach being taken away in the following pages. To remove some of the obstacles that beset the path, and perhaps occasionally to advance a step nearer to the discovery of truth, is all that the ambition of the author dares aspire to. There is no short and summary mode of coming at the secrets of nature, "no bye way that avoids the tedious windings of the great road to science;" and experience proves, that the system-builder who amuses with such promises, only retards the progress of his follower, eventually leaving him no alternative but to remain in error, or measure back his

steps to the slow and certain path of inductive reasoning.

It would argue a want of proper regard for the time and patience of the reader, to revive the old dispute, which should long since have been laid to rest,—whether science and reasoning be at all necessary to the successful practice of physic.

That mind must surely be impervious to argument which requires to be convinced, that he who with experience combines the most enlarged views of the animal economy, is least liable to be perplexed by unusual appearances and varieties which are daily occurring, and require different treatment as the disease puts on new forms and exhibits fresh symptoms, influenced by the constitution of the patient, the variation of climate, or the effect of remedies administered.

However the routine of practice and experience without science may succeed in ordinary cases, where little more than palliatives are required, other talents are called for when precedents are wanting, or not at hand to direct the practice: here it is that general principles are important, and that extensive views of the animal economy can alone serve to guide the practitioner, and prevent that perplexity, which soon loses

sight of every other consideration, but that of its own concealment.

If experience alone were required, the journeyman apothecary, or the hospital nurse might often take precedence of the scientific physician ; but, in reality, where science is wanting, the information that experience alone can afford is very limited, and it generally happens, that the practitioner continues still to blunder ; becomes more and more firmly wedded to his prejudices ; ascribes to nature all the mischief that he does ; suspects any thing sooner than his own insufficiency ; and when striking proofs of it present themselves, he at last wilfully shuts his eyes against conviction.

Our acquaintance with the animal economy is certainly very limited : but it were absurd to contend, that we should therefore disregard the knowledge we possess, and abandon the pursuit as hopeless and unavailing. The more we are conscious of our deficiency the more should we strive to increase our store ; but the truth is, that those who condemn inquiry are already too well satisfied with their competency, and dread nothing so much as the discovery, that they have yet something to learn.

To minds so constituted, reasoning can

make no valid appeal; and waving therefore a discussion so fruitless, I proceed to point out some of the obstacles that seem more immediately to obstruct our progress.

Of the causes which tend to retard the advancement of physiological inquiry, perhaps the most conspicuous is the customary phraseology of the medical schools, abounding in terms that tend to mislead, by the semblance of an explanation, whilst they at best only convey the expression of a fact, but often blend it with an erroneous theory.

Of this nature is the phrase, action of vessels, which with a qualifying epithet is supposd to explain most of the phenomena of disease. Thus inflammation is an increased action of vessels; secretion, a peculiar action of vessels; morbid secretion, an altered action of vessels. In paralysis we have diminished action; cancer is referred to cancerous action; scrofula, to scrofulous action, &c.

That the term action of vessels affords no explanation of the most simple changes of the pulse, must I think appear from duly weighing the following considerations.

Let one hand be immersed in hot, and the other at the same time in cold water; the pulse will soon be found to become fuller

and stronger in the former, smaller and weaker in the latter. No one, it is presumed, will contend, that these opposite effects are produced at the same instant, by the altered action of the heart. It will most probably be said, that heat increases the action of the vessels, and causes increased pulsation in one hand, while cold diminishes it in the other.

Let it now be remembered, that the heart and arteries contract alternately, the heart sending the blood to the vessels, and the vessels impelling it onward again to the heart. But the action of the heart forcing the blood into and distending the vessels, causes pulsation, and not the contraction of the vessels themselves; it is the dilatation of the artery that pulsates against the finger, and not its contraction. How then does increased action of the vessels explain the cause of increased pulsation?

Neither can the increased pulsation in one part of these vessels be referred to increased contraction in another, for all the arteries contract simultaneously, the pulsation being synchronous as nearly as possible in all parts of the body.

If the dilatation then depends upon the impulse of the blood sent from the heart,

how are the opposite effects in the experiment alluded to produced at the same instant? The cause evidently must be, in the one, diminished resistance of the vessels to this impulse, from the relaxing influence of warmth, causing them to yield more readily to the distending force of the blood from the heart; and in the other, an increased resistance in the vessels from the constrictive influence of cold, opposing a greater obstacle to the distending force of the blood sent by the heart, the former increasing, and the latter diminishing the force of pulsation.

It appears then, that the phrase, action of vessels, far from explaining, implies a false theory of the cause of pulsation, the phenomena of which can never be clearly understood without taking into consideration the following circumstances.

First, the pulse may be rendered fuller and stronger in two ways: by the increased impulse of the blood, and by the diminished resistance of the vessels;—and, secondly, it may be rendered smaller and weaker in two ways: by diminished impulse in the blood, and by increased resistance in the vessels. We shall hereafter inquire, when it appears to arise from the one of these causes, and when from the other.

The same phrase, increased action of vessels, is also employed with still less propriety to explain the cause of local congestion, or determination of blood to a particular set of vessels. The fallacy of this must appear sufficiently obvious. As the heart impels the blood into the arteries, and the arteries send it forward through the minute vessels on again to the heart, the blood will accumulate in that part where it meets with least resistance, and not where the action of the vessels is greatest—or diminished and not increased action in the vessels of the part appears to be the cause of local congestion.

Few words are in more common use in medical reasoning than stimulant and sedative, and none are employed in a more vague and indefinite sense, being used to express the supposed property of medicines from the effect they produce ; and although this effect varies according to the quantity of the substance, and the mode of application, the local and general, the primary and ultimate effect being often diametrically opposite to each other, yet the terms continue to be employed with a want of discrimination that equally impedes the discovery of truth and the detection of error. Perplexity and con-

fusion must necessarily prevail in the reasonings where terms so indefinite are employed, as the following instances may illustrate.

A small dose of laudanum often induces intoxication, while a larger promotes sleep: the former termed a stimulant, the latter a sedative effect.

The primary effect of a purgative taken into the intestines is to excite local irritation in the organ, and increase the evacuation; but the ultimate effect is a diminution of general irritation, by the removal of an offending cause.

The local effect of a blister applied to the chest in case of inflammation is to excite superficial, and thereby diminish more deeply seated irritation, by drawing blood from the part inflamed, and causing determination to the seat of the blister.

The local effect of warmth and moisture relaxes the superficial vessels, and causes determination of blood to them; but increased afflux of blood augments the irritability, and thus the warm bath, though primarily sedative, ultimately increases the irritability of the surface.

In short, it might be shewn, that there is no substance in nature but, under some

circumstances, may become either stimulant or sedative, according to their common acceptation; and it is high time that terms, which have become so vague and indefinite in their meaning, should be either properly restricted in the application, or be entirely banished from physiological reasoning.

As it would be fruitless to enter upon the study of the laws by which the animal body is governed, without a previous knowledge of the structure and function of its different organs, those who are not already in possession of it may perhaps find its attainment facilitated by the preceding outline; of which a cursory survey alone may suffice for the more scientific reader.

There is, however, one part of the animal system, not separately described by anatomical writers in general, though often alluded to in pathological reasoning, the changes it undergoes being made the basis of most important doctrines, of which it is, therefore, essential to convey a distinct idea.

This is the capillary system; by which term is not implied any new discovery, or any difference of structure or function from what has been generally admitted; but as the investigation of disease leads to the inference, that the minute prolongations or ramifications

of veins and arteries are often affected, without the larger branches shewing signs of participation, these changes being also productive of effects more immediately connected with the derangement of the general economy; an exclusive term to express this class of vessels, and a distinct definition of its meaning, must contribute to obviate mistakes, and keep in view an essential point of discrimination. The want of this precaution in the writings of Cullen, who often speaks of the extreme vessels, and makes them the primary seat of fever, without sufficiently defining what he means by them, has manifestly involved his doctrine in obscurity.

To avoid misapprehension, when the term capillary system is employed, without any specific epithet, as exhalent, absorbent, &c. affixed, it is meant to imply all those vessels which are too minute in the healthy state to admit red blood, or produce sensible pulsation. These vessels are considered as pervading every part of the living solid, constituting perhaps the larger portion of its substance; and it will be rendered probable that they have a much more remarkable connexion with the state of the brain and nervous system than the larger branches, more important consequences resulting from trifling

deviations from their natural condition. In fact the larger vessels appear to perform only the office of carriers of the blood, while it is through the minute vessels that all the important functions are immediately performed; secretion and excretion, absorption and exhalation, assimilation and decomposition, the evolution of animal heat, and the support of irritability; all which directly depend upon, and bear a direct relation to the tone of these minute vessels, varying with every change they undergo, as will be proved in numerous instances.

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I proceed now to unfold the plan and object of the following inquiry.

The faculties of feeling and moving particularly characterise living animal matter, and upon their exertion the performance of every function primarily or ultimately depends. The laws of life are therefore almost comprised under those of sensation and motion, the investigation of which constitutes the principal object of the present inquiry, and will be treated of in six different chapters, into which the subject seems naturally to divide itself.

The first will be an inquiry into the nature and cause of these faculties.

The second will treat of their several varieties and modifications.

The third, of the connexion between them, and its consequences.

The fourth, of the natural means of supporting and restoring them.

The fifth, of the morbid derangement to which they are liable.

The sixth, of the artificial or physical means of restoring them.

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The mode of investigation will be that of inductive reasoning; but the inferences drawn will always be stated before the arguments are detailed or the facts enumerated from which they were drawn; that the reader, by carrying the inference along with him, may be spared the trouble of reverting to the argument in order to see its application, and may the more easily detect any fallacy in the reasoning.

# CHAP. I.

# NATURE AND CAUSE

OF

# Sensation & Motion.

## SECT. I.

## VITALITY.—MIND.

Of the Vital Principle.——Of the Functions of Mind.——Their Seat and Origin.——Misapplication of the terms Life and Mind.——Feeling may occur either with or without mental Perception.——The terms Sensibility and Irritability used too indefinitely.

THE first question that presents itself to the physiological enquirer is the nature of that principle which distinguishes living from inanimate matter, from which it appears immediately to derive those faculties stated particularly to characterise it, namely, feeling and moving. Many fruitless attempts have been made to solve this problem, and fruitless such attempts must needs be, our very nature precluding us from any knowledge of the essence of matter, or of being in the abstract; all we can attain to is an acquaintance with the resulting phenomena, and the laws by which they are governed, and these are to be learned only by observation and experience:

the question, therefore, respecting vitality, if ever to be agitated, should be the last, rather than the first, proposed.

The next question that suggests itself, is the nature of those functions termed mental, and what distinguishes them from others enjoyed in common by all animal, and perhaps some vegetable matter.

The chief of these appear to be consciousness and volition, which seem to belong exclusively to mind; whereas the faculties of feeling without mental perception, and moving without the liberty of will, seem to be possessed in some degree by all living matter.

In the higher order of animated beings, in addition to consciousness and volition, we have, in various gradations, the faculties of attention, association, memory, judgment, imagination, and invention, constituting the principal of what are termed mental functions.

The functions of mind have been by most physiologists ascribed to the brain; but they have not always agreed about the precise meaning of the term. Some appear to have used it as synonimous to life, among whom may be mentioned the ingenious Dr. Whytt, who was led to infer agreeably to this acceptation, that the mind retains its influence over

a limb when amputated; which certainly gives proofs of feeling, an attribute of life alone, but according to Whytt, of mind.

Had he considered that feeling may exist without consciousness or mental perception, so long as any degree of vitality remains, he might have avoided this paradox by a proper distinction between the terms life and mind.

Feeling and thinking are as much separate functions as hearing and seeing, and though both dependent upon the vital principle, which animates every part of the body, yet they evidently admit of being separately performed, and appear to reside in, or result from different organs, or different parts of the same organ, namely, feeling, from the nerves, thinking from the brain.

Mistakes no less singular have arisen from the vague meaning that has been often attached to the word life.

Bichât, apparently confounding the functions dependent upon the vital principle with the principle itself, was led, from observing that life performed a two-fold function, to ascribe to man two lives; one of which he termed animal, the other organic; to the former referring the faculties of loco-motion and mind, to the latter those of assimilation and excretion.

To establish and illustrate this curious doctrine, which was by no means new, however, [see Barclay on Muscular Motion, page 262] he endeavoured to shew the independence of these principles, by proving that feeling and motion do not result from the brain alone, but that every ganglion is a distinct brain, or separate reservoir of nervous energy, capable of feeling and corresponding to impressions, independently of the brain. Mental perception he ascribed to the brain alone, which he regarded as the chief organ of animal life.

This writer was deservedly esteemed one of the first physiologists of his time, as Whytt was also of his; but as none are exempt from error, so it is the errors of great minds that ought to be most carefully guarded against; those of the vulgar refute themselves.

Allowing that these different functions are respectively performed by the brain and ganglia does not necessarily involve the admission of two distinct vital principles, any more than Bichât's own doctrine leads to the conclusion, that there are as many vital principles as there are ganglia.

The acquisition of a new faculty when the fœtus leaves the womb of the mother, is not the acquisition of a new life: nor till

vitality be shewn to reside in the brain alone, can the inference of two lives be admitted, although a fœtus has grown to maturity, and been born without a head.

What the vital principle is, I shall not pretend to define; but it certainly does not consist in the functions which depend upon it. It is the cause, and not the effect.

Whatever be its essence, this we may safely infer, that it animates every part of the body, performing different functions through different organs; thinking through the medium of the brain, feeling through the nerves, motion through the muscular fibre, as is proved by lesion of these organs exclusively impairing or suspending their respective functions.

Declining, therefore, any inquiry into the origin and metaphysical nature of these faculties, I propose to restrict myself to the investigation of the physical changes attendant upon their exertion; and to avoid misapprehension, from terms that have been variously employed, I shall confine myself to those in most common use, and employ them as nearly as possible in their common acceptation.

Sensibility and irritability are liable to the objections of not being sufficiently ex-

plicit, but conveying either too much or too little for my purpose: thus, sensibility implies the faculty of feeling with mental perception; but I conceive they are not necessarily conjoined. Irritability is commonly used to express the faculty of involuntary motion without feeling; but this involves an assumption which I cannot admit; as I can see no physical power in an impression applied, adequate to produce a muscular contraction, but in virtue of the feeling it gives rise to, exciting the nerve; and I think sufficient reason will appear in the sequel for admitting, that no involuntary motion is produced without a feeling being previously excited, although the mind may take no cognizance of it.

Feeling and thinking are not terms likely to be misunderstood; and for the fact that they may be separately exerted, I may refer to those impressions which are continually corresponded to, without awaking attention in the mind; such as the irritation of the heart and arteries, of the stomach and intestines, and of every vessel that ministers to the function of assimilation and decomposition.

I may go farther, and adduce the instance of an amputated limb, which exhibits

marks of life and feeling in the contractions produced when it is pricked or irritated, after separation from the parent body ; and it will hardly be contended, that the mind is conscious of these impressions ; although Dr. Whytt indeed maintained this opinion, and ascribed to the control of the mind both the feelings and motions excited in the limb after removal from the body. To obviate any objections to this view, he entered into an elaborate discussion upon the nature of mind, endeavouring to reconcile this idea with the opinion of its being neither extensible nor divisible ; a question which appears to me to extend far beyond the reach of human intellect. But I rather imagine, that a doctrine is not likely to find many advocates, which, if the subject be treated on purely metaphysical principles, will tend, (however remote from the author's application of it) in identifying life and mind, either to deny immortality to man, or to confer an equal title to it on the meanest insect that lives.

Both consciousness of the impressions received by an organ and the influence of volition over it, are suspended by cutting, tying, or compressing the nerves communicating with the brain ; the faculty of involuntary contraction, and what has been termed or-

ganic feeling, alone remaining, as mentioned above.

Regarding therefore feeling and thinking, moving and willing, as distinct faculties, I ascribe them respectively to those organs from which experiment shews them to arise, viz. thinking and volition to the brain, feeling and moving to the influence of nerves.

If perception be deemed indispensably necessary to feeling, a distinction must be made between mental and corporeal perception; or, as Bichât terms it, animal and organic feeling; and without admitting the doctrine of two lives, there seems no great impropriety in these terms.

## SECT. II.

## SENSATION.

NATURE and Cause of Sensation.——Darwin's Explanation objectionable.——This Faculty liable to Alteration from Physical and Moral Causes.——Physical Causes considered.——Producing transient Change in the Organs.——One Impression effacing or counteracting another.——Sometimes promoting another.——Repeated Impressions causing permanent Changes in the Organ.——Impressions, how obliterated.——Susceptibility of Impression, why greater in early Life.——Connexion between Debility and Morbid Susceptibility.——Between the State of Sensibility and that of Circulation.——The most Deleterious not necessarily the most disagreeable Impressions.

IT seems hardly deniable that every impression on our organs that either excites sensation or corresponding action, must have induced some transient change or alteration in the part acted upon, which gave rise to that perception or correspondence.

Sensation, then, may be regarded as the result of changes exciting mental perception; feeling, as the effect of changes causing only organic perception, (if the expression be

allowed me) or the result of impressions exciting correspondent actions in the part, but not perceived or attended to by the mind.

The cause of perception, or in what it consists, we are never likely to discover; but it is impossible to conceive that this faculty can be called forth by external objects, without some action or impression on our bodily organs. Thus light impinges on the retina of the eye, and the change induced excites the sensation of vision. The motion of the air beating on the drum of the ear, by the undulations it produces, gives rise to the sensation of sound. Substances applied to the membrane of the nose or tongue, which have chemical action on the fluids, produce the sensations of smell and taste; if insoluble in them, they excite only mechanical impression, as sand taken into the mouth has no taste. In the same way mechanical agents produce a transient impression or change on the organs of touch; and accordingly as they are rough or smooth, hard or soft, give rise to corresponding sensations, which take their name from these effects.

Some change in the organ is necessary to produce a sensation; this is not, however, the sensation itself, but its exciting cause.

Dr. Darwin, in attempting to prove that

sensations and ideas consist in motions of the nervous fibres, seems in some measure to have confounded cause and effect; for if motion in the nervous fibres, the doctrine he contends for, were admitted, still the perception of those motions, and not the motions themselves, must constitute ideas. "To demonstrate that the retina and other organs of sense possess a power of motion, and that these motions constitute our ideas, claims our first attention."—*Zoonomia, vol. I. page* 16, *sec.* 3. i.

When the eye is fixed on a black spot in the centre of a white ground, and after looking at it steadfastly for some time, turned aside to the white surface a spot will appear, brighter than the rest of the ground, corresponding in shape and size to the black one before looked at.

Now Darwin infers from this that our idea of light is not the perception of changes induced, or impressions made on the retina by light as a physical agent, but consists in motions or fibrous contractions excited in the nerve. And thus he reasons:—

If the idea of light arise from changes induced on the retina, "they must either continue as they were received, or not continue at all." That is, a black spot must still

be seen when the eye is turned aside to the plain ground, or no spot at all.

Let us now suppose, that vision consists in the perception of changes induced by the physical action of light on the retina, and see what follows.

Every part of the retina, except that directly opposed to the black spot, will soon have undergone those changes which the light reflected from the white surface is capable of producing, and as the same changes cannot be again induced in exactly the same degree before the former impression is in some measure obliterated, the organ will have partially lost its susceptibility, or that that part will be rendered less capable of undergoing similar changes, until the vital energy has restored it to the natural state, and may thus for a few seconds be incapable of exciting the sensations arising from the impression of light.

But that part of the retina opposed to the dark spot, not having undergone these changes in an equal degree, will retain a higher degree of susceptibility; and when the eye is turned aside, and all parts equally exposed to the impression of the light emanating from the white ground, they will be differently affected by it: this spot will excite

a stronger perception of light, or appear comparatively luminous, and the rest relatively darker.

Darwin's inference is, therefore, unwarranted; nor can any thing be deduced from this phenomenon to invalidate the opinion that some change is required in the organ in order to excite sensation.

Sensation being, then, dependent upon a two-fold cause, namely, changes produced in the organ, and consciousness excited in the mind, is liable to variation in two ways, from altered susceptibility in the organ, whereby it is made to undergo greater or less change from physical agents; and from altered susceptibility in the mind, whereby it is made more or less conscious of the changes produced.

The former of these will first engage our attention; the latter will be considered when we come to treat of moral impressions.

As the living body is continually exposed to the action of physical causes, and exhibits manifest proofs of being affected by them; and as these are the means chiefly to be relied upon for restoring derangement of function, it will be a principal object throughout the present chapter to ascertainhow far the functions of sensation are subject to physical

influence, and their phenomena referable to physical laws.

In pursuance of this object, we have to examine the phenomena of sensation, and inquire what share of them may be accounted for, without adverting to the agency of the vital principle, or calling in the aid of a vis medicatrix, or substituting a final for a physical cause.

We find that an impression upon our organ, if long continued, as that of wine held in the mouth, soon loses its power of exciting sensation; or if several kinds of wine be tasted in quick succession, it becomes difficult or impossible to distinguish them, a fact which seems to admit of the following explanation :—

As perception arises from changes that are going on, and not from such as have been made, every impression requires to be in a great measure effaced or obliterated before it can be repeated; and until sufficient time has been allowed for that purpose, the organ may be regarded as having lost its susceptibility for that particular impression; or the substance applied no longer producing the same changes, no longer excites the same sensation.

Other impressions may, however, be

perceived, as they induce different changes, and therefore excite fresh feelings. It is even reasonable to suppose that the action of one substance may sometimes tend to efface or counteract the changes produced by another exciting changes of an opposite nature; and we accordingly find that a change of impression helps to restore the sensibility of the organ. Thus when the application of opium has suspended for a time the susceptibility of impression, the use of acids is found to counteract this effect, and assist in restoring the faculty of sensation.

On similar principles we may conceive that some substances, acting as it were by a disposing affinity, may promote the action of others, and increase their impression, putting the organ in a more suitable condition for being acted upon; and on this account salt is probably found so useful as a condiment.

Experience teaches us that the habitual use of strong stimulants impairs in time the sensibility of our organs, an effect that may also depend upon physical causes.

As every perception is preceded by a transient physical change, it is easy to conceive that the frequent repetition of it may ultimately alter the tone and structure of the part, as the structure of the mucous membrane

is altered from constant exposure to the air, and the hands become rough from hard labour.

The means by which the physical changes that excite sensation are effaced or obliterated, and thus the susceptibility of the organ restored, certainly belong to vital agency, and therefore bear an evident relation to the activity of the vital principle, which is more fertile in resources during the period of youth, and becomes more feeble and languid as old age approaches.

The immediate agent employed in accomplishing this purpose is probably the nervous influence, which, from its supposed analogy to galvanism, seems peculiarly adapted to subvert and counteract physical action or chemical affinity.

While the facility of restoring the susceptibility of the organs is greater in early life, we find the power of resisting impression in some respects weaker; thus infancy and youth are characterised by a higher degree of sensibility and greater liability to diseases that arise from noxious impressions, than manhood or old age, which well accords with the preceding views.

It is natural to suppose, that the soft and flaccid fibre will more readily experience the

effects of physical agency than the dense and rigid; and we accordingly find, that those causes which impair the tone and texture of the living solid, as unwholesome food, bad air, want of exercise, and other debilitating causes, render the body more susceptible of noxious impressions, and more liable to disease, which affords, on physical principles, an explanation of the connexion between debility and morbid sensibility; the healthy condition of the faculty of sensation appearing to consist in a proper medium between the aptitude to receive and to resist external impressions.

An evident and remarkable connexion is found to prevail between the state of sensibility and that of circulation in an organ: thus diminished circulation impairs the sentient faculty, as in the cold fit of ague, and circulation moderately increased augments the susceptibility of impression, as in the hot fit; and it may be reasonably conjectured, that physical causes have some share in producing this effect.

The circumstances that most conspicuously tend to augment the susceptibility of change from physical agents, are warmth and moisture: the former, by diminishing the cohesion, and thus impairing the resistance of

the organ; the latter, by favouring the approximation of particles, and thus facilitating the action of the physical cause. Now both these effects are produced by circulation moderately increased, and the sensibility thereby augmented. It is only within certain limits however that the powers of sensation can be improved by increased circulation. An inflamed part is indeed more susceptible of pain from pressure on the distended vessels; but the eye, when inflamed, cannot better discern colours, the ear sounds, nor the tongue discriminate between different tastes: if the circulation of the brain be immoderately augmented, confusion of thought, intoxication, or delirium is the consequence.

Experience informs us, that substances which make the strongest impression are not always the most deleterious, nor are the most deleterious always the most disagreeable; and there appears no difficulty in conceiving why it should be so, according to the foregoing principles.

The degree of feeling excited will depend upon the force and rapidity of the change induced; but substances may combine slowly and imperceptibly with our organs, and therefore excite little sensible impression, though their peculiar nature ultimately pro-

duces changes incompatible with the functions of life, and destructive of the vital energy; of such a nature appear to be the changes effected by the contagion of fever, and some mineral poisons, which excite at first little or no sensible impression, because their operation is slow and gradual.

The kind of feeling will depend upon the kind of change; but habit reconciles us to some, and increases our aversion to others: thus the flavour of spirits, tobacco, opium, and a variety of what are termed acquired tastes, are far from grateful before habit has rendered them so;—deleterious are, therefore, not always disagreeable impressions.

Sensation, on the whole, appears to be a passive function, depending upon impressions received by the organs, and communicated through the medium of nerves to the sensorium, where they excite consciousness, or attention in the mind. The susceptibility of the organ, for receiving impressions, is shewn by numerous facts to be impaired by their frequent repetition; although the mental faculty of perceiving, attending to, and discriminating between the different changes produced in the organs, may be considerably augmented and improved by habit.

Motion we shall find, on the contrary, to be an active function, depending upon changes in the moving fibre, induced by the nerves; and the facility of action increases with frequent repetition.

## SECT. III.

# MOTION.

VOLUNTARY and Involuntary.——Other Agents besides Sensation and Motion instrumental to Vital Functions.——Cause of Involuntary Motion.——The Fluids not irritating to their proper Organs.——What kind of Irritation excites the Vital Organs to Action.——Derangement of Function arises when the Fluids become irritating.——Nature of Muscular Contraction.——Cause of Fatigue inquired into.——Not produced by Exhaustion of Nervous Energy.——Four Stages observable in the Phenomena of Motion.——Connexion between the State of Mobility and that of Circulation.——One Muscle has naturally more Strength, and another more Mobility.——What determines each.——Why Exertion increases the Size and Strength of the Muscles.

ALL the motions of the body are performed by contraction of the muscular fibres. Such as can be contracted at pleasure, being under the controul of the will, are termed voluntary. Such as are excited by impressions upon the nerves, and are continually exerted without the interference of the will, are termed involuntary.

But in reality this is only an arbitrary distinction, as no muscles act at all times under

the controul of the will, but all partake occasionally of the nature of involuntary organs, the mind being often inconscious of their efforts.

How the will acts in exciting muscular contraction, there is little probability of our discovering. The question is rather metaphysical than physiological. But experiment shews that it acts through the medium of the nerves, their lesion suspending the powers of motion, as well as the faculty of sensation, in the parts on which they terminate.

Though all the vital functions are performed by muscular contraction, we are not to conclude that it is the sole agent in every function. All ultimately indeed depend upon the faculty of feeling and moving, as all derive their support from materials furnished by the vital motions; but some are immediately performed by a different species of agency.

Thus we have no direct proof of any thing identical with, though it may be analogous to muscular contraction in the function of the brain and nerves, excited to action by the will, or by impressions made upon them. The change which the blood undergoes in the lungs by respiration is a chemical, and not mechanical process. The mixture of the

different secreted fluids with the aliments, forming chyme and chyle in the function of digestion, depends partly on chemical agency. And the deposition and assimilation of fresh matter, by which each part of the body, as bone, muscle, tendon, nerve, and membrane, appropriates to itself such particles of the blood as are fit for its accretion, and lets go such as are become unfit for the purposes of sensation and motion, seem to depend immediately upon a species of elective attraction in each part, a modification probably of chemical and vital agency.

It has been stated, that the will is the exciting cause of the voluntary motions; and organic feeling produced in the part, that of involuntary functions; the nature of which feelings, constantly and uniformly acting, we may next inquire into.

This is commonly referred to a stimulating quality in the fluids applied to the inner surface of the organs; thus the food is supposed to be irritating to the stomach, the ingesta to the intestines, the urine to the bladder, the blood to the heart and arteries, &c.; a doctrine which has always appeared to me highly questionable.

There are only two ways, as far as I am aware, in which substances applied to the

living body can produce physical changes, so as to excite feeling; these are by mere mechanical, or by chemical influence; thus sand taken into the mouth, being insoluble in the saliva, makes only a mechanical impression, and is said to have no taste; salts, acids, and alkalis, from their chemical affinity with the living solid, cause a transient change, which excites the sensation of taste. If then any definite meaning be affixed to the word stimulant, as applied to the fluids of the body, I conceive it must signify this mode of physical action, by which a feeling and correspondent contraction are produced in the living fibre.

When experiment shewed irritation to be necessary to involuntary contraction; and while no other cause to excite it in the vessels presented itself, except what might arise from the fluids contained, it was certainly a natural conjecture, that this must be of a chemical nature; but I think the following arguments will be found to invalidate the inference, that this irritation arises from any peculiar physical action of the fluids themselves, or that they are irritating to the organs with which they are in perpetual contact.

In the first place, the principle assumed appears to be unfounded, resting on a partial

view of facts, and contrary to general analogy. In the second place, if granted, it would not serve to explain the phenomena, which are in opposition to it. And lastly, we have another cause, every way sufficient to account for the phenomena, the presence of which cannot be denied, and which is liable to none of the foregoing objections.

First, the principle assumed appears erroneous. We have no instance of any stimulant that continues uniform in its effects if kept for any considerable time applied to our organs; thus our tastes are continually varying; medicines, if constantly used, either lose their influence, or produce constitutional effects; and even the most virulent poisons in time become habitual, and cease to excite irritation. It seems, therefore, contrary to general analogy that the blood and other fluids, natural as it may be said, to the organs with which they are in perpetual contact, should excite irritation.

Secondly, this principle, if granted, cannot explain the phenomena, but is in opposition to them. The inner surface of the heart and arteries is in perpetual contact with the blood, supposed to stimulate them to action; but if the action of one be suspended, that of the other ceases, though there still remain blood

enough to act upon the vessels, if they were sensible of it; and it appears that the action of both varies continually in exact relation to the degree of force and velocity with which each is mechanically distended by the impulse of blood sent from the other, and not to its physical nature, which is nearly constant and uniform. The stomach shews no signs of irritation from receiving the food, but gradually yields for its admission, until a certain degree of distension excites resistance, when it begins to contract for its expulsion. The intestines, in like manner, when distended by the ingesta, contract and impel them forward. The rectum, until sufficiently distended, does not contract for the expulsion of fœces. The bladder, though in contact with the urine, shews no signs of irritation until it begins to be painfully distended, and is then soon relieved by only a partial depletion.

Lastly, we have, as already stated, in mechanical distension a cause fully adequate to the explanation of the phenomena, and liable to none of these objections. Thus while reason and experience concur to prove that chemical stimuli can never be long uniform in their effects, as they act by combining with the organ, and are therefore liable, by frequent repetition, to alter its tone; no such

objection applies to mechanical impressions, which may be regarded as inducing (unless powerful enough to cause lesion of structure) only a transient change in the arrangement of the particles composing the moving fibre, which is quickly restored, and leaves no permanent effect.

The variety of impressions which the feeling principle has to correspond to at the same instant has long been a matter of surprise; perhaps this variety is not so great as it appears.

Respiration is the only important involuntary function that remains to be accounted for; and this seems to arise from a sense of oppression in the lungs, which is removed by enlarging the capacity of the thorax. Now this enlargement may permit the elongation of the vessels, and thus facilitate the transmission of the blood, whereas any obstacle to it must necessarily give rise to over-distension of the vessels. Accordingly suspended respiration is a frequent cause of hæmorrhage.

Of the other involuntary organs I have already spoken; but many of the voluntary are continually exerted without any sensible act of volition; and we shall now inquire what cause seems to excite them to action.

Distension and extension, it will be readily admitted, are only modifications of the same

impression, and this last appears to be the natural stimulus to such voluntary muscles as are continually exerted without an effort of will. The head would immediately fall forward by its own weight, and extend the muscles at the back of the neck, if this extending force did not continually excite them to contraction. The lower jaw, if its weight did not stimulate the muscles that support it, would fall, as it often does when a person sleeps with the body erect. In walking, the muscles of the back and abdomen are in the same way prompted to keep the body in equipoise; and all muscles that have antagonists are more or less subject to a similar species of influence, the effects of which are often conspicuously felt when a sudden extension excites a violent and involuntary contraction, and causes what is termed a sprain, which often affects the opposite tendons to those on which the force was directly applied; the reaction of the antagonist muscles causing the principal injury. The sphincters also are excited by internal pressure, a mode of distension from the fluids contained; but there are some which seem to be exceptions; thus the mouth has no internal pressure, and no involuntary action. The eye-lids may be somewhat distended by the prominent roundness

of the eye-ball, which excites them to action till sleep approaches, when fatigue and relaxation cause them to drop.

That mechanical distension contributes to excite vascular action was long ago suggested; but that it is the only natural and uniform cause exciting organs that are continually acting, has not, so far as I know, been yet advanced; further reason, I trust, however, will appear in the sequel for admitting this opinion.

Fluids that are liable to frequent and conspicuous changes may no doubt become irritating to the organs to which they are applied; thus the food may become irritating to the stomach, the urine may become so to the bladder, or the blood to the vessels; but these are morbid effects, and attended with derangement of function. Medicinal substances owe their efficacy in producing inordinate action entirely to this principle; and those fluids which are only occasionally applied, as bile to the intestines, may possibly be admitted to act in this way; but if granted, these are no exceptions to the rule, that fluids uniform in their nature and application are not stimulant to the vessels; no organ secreting a fluid to irritate itself.

Before we attempt to investigate the laws

of motion, we must ascertain as nearly as possible what muscular contraction is.

The opinion which I believe to be most generally received, and certainly the most probable, is, that it consists in a closer aggregation of the particles constituting the muscular fibre, effected by the intervention of nervous energy.

Haller seems to have regarded the nerve as only the exciting cause of contraction; Whytt, as the immediate cause, or means of inducing this state of the muscle. The opinion of Whytt seems more probable, while that of Haller only accumulates difficulties, by assigning no immediate or efficient, but multiplying remote or exciting causes. Thus the will in voluntary, internal stimulus in involuntary motions are exciting causes acting upon the nerve: why then make the nerve also an exciting cause, and ascribe to a vis insita in the muscle itself the faculty both of perceiving and corresponding to the impression, that is, both of feeling and moving?

It seems more probable that the nervous energy then is the means of inducing a closer aggregation of particles in the muscular fibre; but on what principle, or in what manner, we may not soon be able to discover.

As we know only one agent in the material

world capable of instantly penetrating solid bodies, of modifying the attraction of aggregation, and subverting all chemical affinities, namely, electricity; it is not improbable, as this agent must at all times pervade the animal body, that some modification of it may be employed in the animal economy as the means of accomplishing those changes necessary to muscular motion, and of repairing those that give rise to sensation. It may also contribute to the performance of other functions, especially the evolution of animal heat, for there certainly exists between heat and electricity an affinity not very remote. But when I employ the term nervous energy, I mean no allusion to any particular theory of its nature, a subject on which I have no settled opinion, conceiving the idea that the nerve imparts a fluid to the muscle not more probable than that it may abstract something from it in causing muscular contraction.

That the nerve by some means does produce an instantaneous change in the aggregation of the muscular fibre, seems to be proved by the phenomena; and in whatever way it be accomplished, the agent that produces such important changes must needs be a very powerful one; nor does it appear at all surprizing that its frequent and continued

application should eventually produce changes in the organ acted upon, which excite, like all other changes when they become excessive, a painful sensation.

This I conceive to be the cause of what we denominate fatigue, whether employed to denote the aching sensation that remains after over-exertion, or the acute pain that arises from its continuance.

The exhaustion or expenditure of the nervous fluid, the cause to which this change in the powers of action is more commonly ascribed, involves the assumption of a very dubious principle, which, if granted, is irreconcileable with the phenomena; while they may all be shewn to accord with the view just given.

In the first place, the very existence of a fluid generated by the nervous system might be questioned; but granting this, its exhaustion being a cause of pain is far from probable, and the exhaustion itself not by any means proved.

The nerves of voluntary motion are supposed to derive this fluid from the brain, and not to generate it themselves; exhaustion should, therefore, affect the source from whence it is derived, and not excite pain in the part to which it would have been sent.

Why pain should arise in a part for want of something to act upon it, is not explained, nor very intelligible.

But this exhaustion itself is highly questionable, or continuance of exertion should uniformly produce an aggravation of the pain, and a diminution of the power of action.

Yet we find the soldier sinking under the fatigue of a long day's march suddenly recruited by the appearance of an enemy, by the hope of glory, or the apprehension of danger. It can hardly be supposed that this cause has unlocked a new source of nervous fluid.

But if granted that exhaustion takes place, the assumption that this is the cause of pain is irreconcileable with the phenomena.

When a nerve is cut or tied, which effectually prevents the nervous influence from being exerted over the organ to which it leads, loss of power in these parts, and not pain, is the consequence.

The pain of fatigue is often removed by mere change of action; but as all the fibres derive this supposed fluid from one source, all should feel the effect alike, and in fact the exertion of one organ should cause fatigue in another, or in all.

Sometimes the effects of fatigue remain

for several days, in which case a very long period must be supposed requisite for restoring a proper accumulation of the nervous fluid.

But on the supposition of the power of action being dependent upon the quantity of nervous energy, the degree of power should be greatest at the period of the greatest accumulation, which is immediately after sleep, or the moment we awake in the morning; and this power should gradually decline as the accumulation is exhausted, towards evening.

This, however, is not the case, most persons being as strong in the evening as in the morning; and instead of the powers of action decreasing, they often increase by exertion; thus the first dance in a ball-room is generally the most fatiguing.

The phenomena appear then not to accord with the assumption. We now proceed to inquire whether they agree with the inference of the pain of fatigue arising from changes induced in the moving fibre.

It is not unreasonable to suppose that our efforts at first will be productive of a less regular and uniform application of the nervous influence, than afterwards when a little practice has brought us into the way of

regulating our motions, and enabled us to perform them with skill and dexterity.

In this way the first dance in a ball-room may be fatiguing, because the nerves exert their influence immoderately over some fibres of the muscle, and defectively over others; but afterwards, when this influence is uniformly and efficiently applied to every fibre, our efforts are less awkward, and our strength and activity increase.

After a certain time, however, exertion becomes painful, though not in such a degree but that an additional incitement will make us forget the pain, and renew our efforts, as a stronger effaces a weaker impression.

In this stage the fibres may have undergone such a change as renders action rather irksome to us, but without inducing any thing like incapability of contraction. It may be, that particular fibres having undergone changes, may be rendered less capable of contraction, and a more powerful exertion of the nervous influence, now called for, may give rise to its immoderate application to those which have been less exerted and retain a higher degree of susceptibility. This will of course produce inordinate action in the latter, and occasion the sense of pain; and the occurrence of spasms or cramps, which are not

unfrequent on the approach of fatigue, confirms the probability of the nervous influence being immoderately applied to particular fibres. But after exertion has been continued for a length of time sufficient to produce the same changes in an equal degree in all the fibres, motion becomes difficult, a diminution of power ensues, and at length a total suspension of it in those organs which have been exerted; while its retention in others which have not been equally employed, indicates the moving fibre to be the seat of exhaustion, and not the organ that supplies nervous energy.

But some direct proof may be required of the muscular organ being the immediate seat of these changes; and were physiologists more disposed to reason from facts which observation presents than from fancied hypotheses, this proof would not have been so long disregarded.

Pain, redness, heat, and swelling, or, in other words, local inflammation, is the usual consequence of over-exertion, indicating changes in the moving fibre, more definite in their nature, and more permanent in duration, than what are commonly implied in the terms—nervous affection. The investigation of the nature and cause of inflammation,

and the various approximations to this state, would be premature in this part of our inquiry.

The similarity between the pain of rheumatism and that of fatigue is too obvious to be overlooked; and, although actual inflammation may not occur if exertion be suspended in time, this resemblance indicates an incipient stage of it, which would in all probability have proceeded to an inflammatory state had action been long enough continued.

Thus then the phenomena accord with the inference, that fatigue, if used to express the pain from over-exertion, arises from too-long continued or excessive application, and not exhaustion of the nervous energy; and if used to denote the loss of power that follows over-action, is the result of changes that have been produced in the organ acted upon, which render it insusceptible of the nervous influence until it has experienced the renovation derived from food and rest.

An interesting but difficult subject of inquiry is the connexion that prevails between the state of circulation and that of mobility.

Cold, which impedes circulation, diminishes the power of motion; moderate warmth, which accelerates it, augments this power. Quickened circulation attends

exertion, and increased heat resulting from it augments the facility of action.

What share the blood may have in contributing to muscular contraction, our ignorance of the nature of nervous agency forbids any attempt to explain. Otherwise, did it not appear too bold to hazard a conjecture, one might be disposed to suggest, prompted by the apparent analogy between the nervous and the galvanic energy; and again, by the affinity between heat and electricity;—that the effect had some relation to this connexion, warmth probably rendering the muscular fibre more susceptible of the nervous influence.

Speculations concerning the nature of the nervous energy, however they may amuse, cannot be said to instruct us; and the only use intended to be made of this hint, is to shew, that the generation of a fluid by the nervous system may admit of a doubt; the phenomena of muscular motion being explicable on the supposition of something analogous to the electrical energy, which must at all times pervade the animal body, without the necessity of its being generated in the system

It is more consistent with sound philosophy to reason from facts than to form conjec-

tures. Let us then attend to the phenomena of motion, and see what they present.

We observe here four distinct stages between the commencement and the cessation of action. At first, feeble and somewhat difficult;—then powerful and efficient;—then again painful and difficult exertion;—and, lastly, partial suspension of the powers of voluntary motion.

These facts will be made the basis of some important reasonings, and not the explanation of their cause, however plausible that explanation may appear, or how strongly soever it might be supported by arguments.

These stages, as experience shews, run their course more or less rapidly in different constitutions. Thus in youth or childhood, in persons of soft and flaccid fibre, and of irritable habit, the period of greatest activity soonest arrives, but that of painful exertion most quickly succeeds. In manhood, and in persons of firm and dense fibre, the degree of mobility may be less, but the power of supporting continued exertion is greater. But they are also liable to the greatest variation in the same constitution at different times.

The natural strength of a muscle may arise from the number of fibres it contains; [Richerand's Physiology, page 318] but the

occasional strength depends in great measure upon the tone or density of each particular fibre; as a small muscle, if firm, may be stronger than a large one.

Obesity, instead of conducing to strength, is unfavorable to it, and the very means that increase the strength remove corpulency. Indolence and sleep promote the latter; active exertion increases the former. Of this we have instances in children before they begin to walk, and domestic animals which grow fat for want of exercise. Haslam remarks, that maniacs, who from loss of the mental faculties have sunk into a state of apathy, usually grow corpulent; and I have been informed, that criminals under sentence of death, if from any cause their execution be delayed, usually fatten, if well fed, before their death.

The influence of active exertion in removing obesity, but at the same time in augmenting the firmness of the muscles, is familiar to every one; as seen in the arm of the blacksmith, and in various instances in the lower animals. Thus horses diminish in bulk, but increase in strength and muscularity from regular exercise. For which the following explanation may be offered:

Many circumstances concur to shew, that

the process of absorption goes on most rapidly during exertion; and that of deposition during rest. Now it is natural to suppose, that those particles will be soonest absorbed which are retained by the weakest affinity; and thus exertion will tend to remove obesity, but to increase the density of a muscle.

But exertion indirectly tends to augment the growth of the muscle in the following manner: Increased action in the minute vessels attending exertion, will be succeeded as we shall hereafter find, by a more perfect relaxation and more full circulation through these vessels during the subsequent period of rest; and thus will the materials for assimilation be more abundantly supplied, when action no longer interrupts the process of deposition.

The powers of action are also liable to be affected by all causes that alter the energy of the brain or nervous system without any primary change in the moving fibre. This is illustrated in the influence of the passions, when fear unnerves the strongest arm, and rage supplies the weakest with unusual energy. The consideration of these causes must be reserved for another part of this inquiry.

## CHAP. II.

# VARIOUS MODIFICATIONS

OF

# Sensation & Motion.

## SECT. I.

## VARIETIES OF SENSATION.

SENSIBILITY modified by Structure.——Sensations peculiar to different Organs; as the Eye, the Nose, the Ear, the Tongue, &c.——Their Physical and final Cause.——Modes of Feeling possessed by other Organs.——Hunger peculiar to the Stomach. ——Thirst to the Fauces.——Griping to the Intestines.—— Itching to the Cuticle.——Heat and Cold to the Cutis Vera. ——Lassitude to the Muscles.——Contorsion to the Ligaments and Tendons.——Aching to the Bone.——Aptitude of these Sensations for the Purposes they answer.

EVERY part of the body that differs from another in structure has also a different modification of feeling and action: from whence it results, that the same cause applied to both may produce in each very different effects. Fluids that are grateful to the tongue, give pain when received into the nostrils; what excites itching on the skin, causes intolerable smarting when the cuticle is abraded.

Several writers have slightly touched upon, or vaguely hinted at, the different modes of feeling possessed by particular

parts of the body, but none that I am acquainted with have fully investigated this circumstance, little progress having hitherto been made in an inquiry, the importance of which must sufficiently appear in its enlarging our views of the animal economy, and facilitating the means of ascertaining the precise seat of internal diseases. Some indulgence, therefore, is due to the novelty and difficulty of the subject; and the following remarks should be received rather as matter of opinion in some instances than as definite conclusions.

Of the organs of sense, strictly so called, there is little occasion to speak, their mode of feeling being familiar to every one, and their structure explaining in great measure why each has a mode of sensation peculiar to itself. Thus light alone can be perceived by the eye, odours by the nose, taste by the mouth, sound by the ear; because the structure or mechanism of each of these organs excludes the agency of other causes, while it transmits and modifies the one received.

Now if we find peculiarity of form and structure accompanied also in internal parts with peculiarity of feeling, we may venture from analogy to presume that the same connexion still prevails between sensibility and

structure, although the nature of this connexion may be sometimes less obvious to our conception. And this we may infer to be the physical cause of the different modes of feeling, which we accordingly observe between bone, tendon, vessel, muscle, and membrane. The final cause why this variety of feeling belongs to internal parts appears equally manifest with that of the external organs of sense, both contributing to the performance of functions essential to the well-being of the animal, differing only in the objects to which each has relation. By the one we are made acquainted with the sensible qualities of external objects; by the other we are made to perceive the internal changes of the body, and receive timely notice when they induce such derangement of function as may be prejudicial to the animal economy.

The sensations of hunger and thirst are confined to the stomach and mouth, and give us notice of the changes these organs undergo, prompting us to seek instinctively the means of relief.

The sensation termed griping is no where excited but in the intestines, though the term may be sometimes metaphorically used to express other sensations which bear an affinity to it.

The sensation we call itching is never experienced on any parts but the skin or mucous membrane; it is therefore confined to parts exposed to the air, occurring, as suggested to me by a friend, only where this membrane is covered with cuticle. Cuticular eruptions produce this sensation, but not such as are more deeply seated. The healing or skinning of an ulcer is accordingly denoted by the return of this sensation. It occurs also in the eye, the nose, and the fauces, and produces a flow of tears, sneezing, or coughing, by which the irritating cause is removed.

The sense of heat and cold, as Dr. Currie remarks in his Medical Reports, is almost confined to the surface, or very vaguely felt in internal parts; the term burning pain being used metaphorically for want of a more precise one to express this feeling. The frequent conjunction of an additional epithet, as a burning gnawing pain, confirms the idea of its being an approximation only. The near resemblance between the sense of heat and smarting, which arises when increased afflux of red blood to the minute vessels of the cutis or the mucous membrane takes place, leads to a conjecture that these are the proper seat of the sensation. Accordingly we find irritation of these organs attended by it, as in

erythema and erysipelas, while in small pox and eruptions more deeply seated, this sensation does not occur, except when produced by the general fever which affects all parts. We may perceive also the cause of a similar feeling when the mucous membrane is affected in heartburn and erythematic inflammation of the stomach.

The sense of lassitude or weariness seems, as I think Bichât remarks, to be felt only in the muscles, other causes as well as fatigue giving rise to it. Thus the pain of rheumatism closely resembles it, and in fever it is very distressingly felt.

The sense of contorsion, or that acute pain which attends injury of the joints, as a sprained ankle, is not, so far as I am aware, perceived any where but in the ligaments and tendons. Bichât, in endeavouring to ascertain by experiment whether the ligaments had any sensibility, carefully separated the surrounding parts from the leg of a dog, and then irritated the ligaments in various ways. The dog evinced no sign of pain when they were cut, burnt or squeezed, but strikingly evinced his suffering when they were twisted. Bichât therefore inferred, that they could feel pain from no other cause; but this inference seems unwarranted, as they

feel pain from inflammation also. From the resemblance of this pain however to that of contorsion, as when excited in gout, this seems to be the mode of feeling peculiar to these organs.

The sense of aching I conceive to be confined to parts contained in or surrounded by bone, or to be that modification of feeling produced by bone, probably arising from the undue pressure to which the nerves (these being still the ultimate organs of feeling) are necessarily exposed when increased determination of blood to those parts takes place. Thus the tooth-ache arises from whatever determines blood to the tooth; head-ache is produced by undue determination to the head; what is termed rheumatism of the face may result from the undue pressure of the facial bones upon the nerves and vessels, in a state of chronic inflammation; ear-ache in the same way may proceed from the bones of the internal organ of hearing; nodes on the skin and on the forehead also produce the same intolerable sensation.

That each part should have a mode of feeling peculiar to itself, seems expedient to enable us to judge with tolerable accuracy of the seat of derangement, and there appears to be a remarkable aptitude between

the sensation and the organ it is meant to protect. Thus aching is excited by undue pressure, the cause from which bone is most liable to suffer; distorsion is most likely to injure the joints, and is peculiar to ligaments which serve to prevent it. Fatigue or over-action may be injurious to the muscles; hence the sense of lassitude is confined to them. Internal parts are seldom exposed to vicissitude of temperature; the surface is therefore most sensible of this impression. Itching, if perceptible in internal organs, where the hands could afford no relief, would be a source of constant misery, and is felt therefore only on the cuticle.

I am sensible that these observations are very far from exhausting the subject, and shall rejoice to find the attention of others directed to it, few points of physiology opening a finer field for experiment and inquiry.

Before we proceed to examine the varieties of motion, it is necessary to notice an important corollary that seems to arise out of the preceding views.

As the sensibility of each nerve is modified by the peculiar structure of the part on which it terminates, it necessarily follows that the organized sentient extremity must be

most susceptible of those impressions which it is peculiarly calculated to receive.

It has accordingly been admitted in some measure as an axiom in physiology, that the extremity is the most sensible part of a nerve; a law which would appear, from the foregoing statement, to be admissible only under certain limitations.

In illustration of the truth of this principle, when properly restricted, we may adduce the peculiar sensibility of the mouth of every vessel, and the termination of every duct that opens upon the internal surface of the body; the substances which are most calculated to make an impression upon these or any particular organs, and the kind of change they may induce, being points which can only be ascertained by actual experiment.

## SECT. II.

# VARIETIES OF MOTION.

A DEGREE of Power allotted to each moving Organ, proportionate to its Function.——Their Mobility or Range of Action inversely as their Tone or permanency of Action.——This Law illustrated in the voluntary Muscles.——The same Peculiarities characterize them in Health and Disease; exemplified in Chorea and Tetanus.——Influence of Habit in modifying this Law.—The same Law prevails also in involuntary Organs; illustrated by Examples.——The probable Degree of Action peculiar to secreting Vessels.——Peculiarities of the Mouths of Vessels; their Contraction alternating with that of the Vessels themselves. Probable Cause of this.——The Law respecting Mobility and permanency of Action extends also in some Degree to the Organ of Mind.

THE varieties of motion are no less remarkable than those of sensation; but I am not aware that the points to which I am desirous of directing the attention of the reader have ever been separately considered, or distinctly treated of by anatomical writers, although their importance in pathological reasoning is too obvious to be denied.

Every organ requires for the healthy performace of its function a certain degree of mobility or range of action on the one hand, and a power of continued exertion, or permanency of contraction on the other; and these will be found on a careful examination to be almost in an inverse ratio to each other, the degree of force and permanency decreasing as the mobility and range of action increase.

The importance of attention to these peculiarities, rests upon its enlarging our views of the nature of the moving powers, upon this knowledge being essential to the explanation of the phenomena attending every vital function, and upon the fact, hereafter to be illustrated, that the same peculiarities which characterize different moving fibres in health continue also to predominate under the influence of disease.

The range of action and the power of continued exertion peculiar to different organs are considerably various, both in those which are subservient to the will, and also in those which are exempt from its controul. I shall begin with the examination of the former, because they are more obvious and familiar, and because their excessive exertion is immediately announced by the mental

perception of pain or fatigue; whereas we only judge of it in others by the derangement it induces.

Beginning with the voluntary muscles,—those at the back of the neck support the head, or prevent its falling forward during the whole day; and those of the back and abdomen keep the body in equipoise for twelve or eighteen hours together, without growing weary; and yet whoever continues to move his head or his body in an unusual manner for any length of time, will soon find that these parts are susceptible of fatigue from an excessive or unusual exertion.

The muscles of the lower extremities are more capable of diversity and promptitude of action than those of the neck and back, but sooner experience fatigue; and the mobility of the upper extremities is still more conspicuous than that of the lower, while their power of supporting permanent action continues to descend in the scale; a fact of which any one may satisfy himself, by attempting to keep his arm extended for a few minutes.

The fingers have still more mobility, and less permanency, as appears from the variety of motions rapidly performed by a skilful musician, or a quick writer; while the same

person may be unable to keep his hand firmly closed for a few minutes without fatigue. The muscles of the organs of voice are eminently conspicuous for mobility, but less so for tone and permanency, as they continually obtain relief by change of action, but become tired if the same action be long continued. Thus we soon experience fatigue from continuing to press the tongue with moderate force against the palate.

The fact that the same peculiarities which characterize different moving fibres in health are retained to a certain extent under the influence of disease, and perhaps render some more susceptible than others of particular affections, is illustrated in the examples of chorea and tetanus.

Chorea, which consists in irregular and frequent contractions, soonest affects those organs most conspicuous for mobility, as the muscles of the organs of speech, (stammering being of the same nature as chorea); those of the face and the fore part of the neck causing irregular motions of the head, or twitching of the face; the hands and fore-arm commonly, and sometimes, though less frequently, the lower extremities are also affected.

Tetanus, which consists of what are termed tonic spasms, or more permanent contractions,

is more liable to affect the muscles that are conspicuous for strength and duration, rather than rapidity and diversity of action. Those first affected are generally the muscles supporting the lower jaw, producing locked jaw, which of all voluntary muscles are perhaps most remarkable for force and continuity of contraction, as they never entirely relax till the brain deserts its office, when the falling of the jaw announces approaching dissolution. The next most liable to participate in this affection are those of the neck, then those of the back and abdomen, drawing the body backwards, or bending it forwards, technically termed opisthotonos and emprosthotonos. The muscles of the shoulders also participate, the flexors of the fore-arm, the calves of the legs, and the ball of the thumb; all parts more remarkable for their force and continuity, than for their rapidity and frequency of contraction.

The cause of these peculiarities in different moving fibres may be partly derived from original difference of structure, and partly from the influence of habit, "a second nature," as it is emphatically stiled. The power of habit over voluntary muscles is too well known to require illustration; its in-

fluence over those of involuntary motion, though less familiar, is not less remarkable.

The experiments of Spallanzani strikingly illustrate its effects on the organs of digestion. He taught eagles to live on vegetable, and sheep on animal food, which they at length accomplished without any apparent inconvenience.

The force of habit over the organs of respiration is conspicuous in persons trained to running, who can support the severest exertion for any time without feeling oppressed; and in divers, who can suspend their breath for some minutes without difficulty.

What chiefly demands our attention at present, however, is not the origin so much as the consequence and effect of this peculiarity which characterizes different organs; its influence remaining the same, whatever be its cause; and this influence extends to, and is connected with the due performance of every function, in all of which we shall find the same principle to prevail that the power of continued action diminishes as the range and variety increase.

As we proceed in the inquiry into the powers of different moving fibres to parts that are not under the controul of will, we no

longer find the approach of over-exertion announced by a sense of fatigue, which would here be a source of misery only, as the will has no power of suspending those actions which gave rise to it. The physical cause of this want of consciousness in the mind of the changes induced in organs of involuntary motion, may be sought for in the distribution and immediate origin of their nerves; these organs being less amply supplied with cerebral nerves, which are with apparent reason supposed to be most calculated to excite mental perception, and to obey the dictates of the will; but deriving their power of feeling and moving from the gangliac system, which seems to admit only, from ordinary impressions, of what I have ventured to term corporeal perception.

Though the sense of fatigue be wanting, we have abundant proof of the same changes arising from over-action in involuntary as well as in voluntary organs, from the derangement of function produced.

The range of action peculiar to the vascular system is limited to the alternate enlargement and diminution of the capacity of vessels; but considerable diversity prevails here also in point of force, permanency, and extent of contraction.

Of all vascular organs, the stomach admits perhaps of the greatest range of dilatation and contraction, as it usually undergoes a more or less perfect repletion and depletion twice or thrice in the day; and the degree of contraction that is exerted by the organ must vary according to the state of depletion; when its distension is greatest, the extent of contraction required to expel a portion of its contents will be least; and as its depletion advances, the efforts of contraction must keep pace with the increasing depletion, or the contents will cease to be expelled. Habit seems, however, capable of increasing or diminishing the extent of its exertions; thus eating frequently before we are hungry tends to impair the tone and energy of the stomach; whereas eating after moderate fasting, at regular stated periods, improves the powers of digestion.

The intestines seem to possess a less extensive range of action, but more permanency than the stomach, their repletion and depletion being more gradually and uniformly accomplished, as the ingesta received into the stomach are only transmitted by degrees to the intestines, and are propelled in the same uniform manner to the colon.

This organ, which is probably at all times

in a state of repletion, has still less range of action than the other intestines, requiring the assistance of the abdominal muscles to expel its contents ; but it appears to possess a more considerable share of permanent contraction, opposing an uniform and constant resistance to the force distending it.

The rectum, at least its lower extremity, seems rather to be in a state of constant depletion and contraction, passively yielding to the distension arising from the fecal matter descending from the colon, if gradually produced, but resisting distension if sudden or excessive; either assisting in the evacuation of the intestines in the healthy state, or producing obstinate constipation in case of immoderate accumulation of feces.

Thus there appears to be a regular gradation from the stomach to the rectum, the mobility and range of action diminishing as we descend in the scale, while the permanency of contraction increases. We shall find also the same gradation in the sanguiferous system, from the heart and arteries descending down to the capillaries and sphincters or pores.

The heart, like the stomach, undergoes a state of alternate repletion and depletion, but is more limited in its range of action and more constant in its exertions than that

organ, being continually distended by the blood sent forward by the contraction of the arteries, which it as uniformly propels again to these vessels.

The arteries, which are never emptied, have consequently a more limited range of action than the heart, and contract more uniformly and gradually so as to equalize the flow of the blood.

The veins, which perform a more passive function than the arteries, transmitting their contents, but contributing little to their propulsion, afford a more regular and uniform resistance to the distending blood within them, and have therefore more permanency with less mobility of action than the arteries.

The capillaries have still less range of action than the veins, and more permanency of contraction, or tonicité, as Bichât terms it, the calibre of the secreting vessel (according to Haller's idea of secretion, and the very simple and satisfactory view of this function given in Murray's System of Chemistry,) admitting only those particles, the diameter of which is less than that of the vessel itself, so that their dilatation and contraction must be very limited, as some never admit red blood, and others only the thinner parts of the white serum. Any change in the condition of the

vessels must necessarily produce change of function according to Murray's view, which I shall briefly state.

As all the materials of the secreted fluids are derived from the blood, separation of these and recombination constitute the function of secretion, which is conceived to take place in the following manner:

The small vessels becoming gradually more and more minute, separate the component parts of the blood propelled into them by the larger, and the balance of affinities being thus destroyed, fresh combinations are produced by certain parts being brought together according to the distribution of vessels in each particular gland, and the remainder of the materials are carried back into the common mass of the blood.

This short and imperfect sketch is sufficient to shew how change of secretion must follow from any alteration in the degree of contraction in the secreting vessels. If their capacity be diminished, the smaller particles alone will be admitted, and the secretion may be rendered thinner and more sparing; thus we have pale limpid urine in the cold fit of ague. If their capacity be increased, the larger particles, which should be separated, will be mixed with the secreted fluid, and its quantity

may be thus augmented, while its quality is vitiated; thus we have high-coloured urine in the hot fit of fever, and increased but vitiated secretion from the mucous membranes in chronic catarrh, ophthalmia and other inflammations. Every inflammation of a secreting organ is not, however, attended with increased secretion, for reasons hereafter to be explained.

The last class of moving fibres to be noticed is one whose existence has never been disputed, though its attributes, as far as I know, have not yet been investigated; on this point, therefore, it is necessary to enlarge a little.

The organs to which I allude are the pores or mouths of vessels terminating on the external or internal surface of the body; their office consisting in the due retention or transmission of the fluids contained. They appear to be in every respect analogous in function and attributes to the sphincters of other involuntary organs, as the stomach, the rectum, and the bladder. They are excited to contraction by the same cause, namely, internal pressure or distension, which they resist with a force corresponding to the distending power. When this power is sudden and violent, they become obstinately constricted, analogous to the effect produced in the pylorus by over-

distension of the stomach, in the sphincter of the rectum by immoderate accumulation of feces, and in the neck of the bladder by excessive distension with urine; and accordingly we have a hot and dry surface from constriction of the pores when the vessels are overdistended in the hot fit of fever, or in local inflammation.

Like the sphincters of these organs, they appear also to become relaxed from similar causes. We find the pylorus relaxes from emetics which excite increased contractions in the stomach, and bile is thus ejected through this organ in vomiting. Purgatives which increase the contractions of the circular fibres of the intestines, often so much relax the sphincter of the rectum, as to cause involuntary evacuations. Diuretics which probably irritate the vessels of the kidney, and perhaps also the bladder itself, cause the ducts of the one and the sphincter of the other to relax, and hence excite micturation. In like manner, it is probable that sudorifics act by exciting increased contraction in the exhalents, thence relaxing the pores and promoting perspiration. Hæmorrhage which causes the blood-vessels to collapse, also relaxes the pores, and causes a cold sweat, the usual precursor of syncope.

As distension appears to be the natural stimulus to these, as well as other involuntary organs, we may conceive the following to be the reason of this curious fact, that the mouths become relaxed from every cause that tends to constrict the organs that lead to them; and, on the contrary, become firmly constricted from causes that relax and over-distend the vessels.

Whatever distends the vessels increases the column of fluid transmitted to their mouths, and thus augmenting the pressure to which they are exposed, excites them to increased resistance; but whatever contracts the area of the vessels lessens the column of fluid that passes to their extremity, diminishes the distension to which they are exposed, and consequently removes in part the cause that excites them to resistance. Were it necessary to carry the analogy further, it might be observed that they are alike affected by passions of the mind; thus fear, which sometimes relaxes the sphincters and causes involuntary evacuations, acts also on the pores, and is attended with a cold sweat. All causes that constrict the vessels, it may be remarked, do not cause transpiration, as the constriction of the vessels may be such as to prevent the fluids

from arriving at their extremity, hence we have no transpiration in the cold fit of ague.

Now as the function of these organs consists in retaining the fluids, or suffering their transmission in suitable quantity, a power of permanent contraction appears essential to them, and we accordingly find in fever and inflammation, that they remain constricted for days and weeks together, and are perhaps, of all organs, endowed with the greatest power of permanent contraction, while their range of action is proportionally limited.

We see then that each class of moving fibres has a range of action peculiar to itself, and consistent with the function it has to perform. All are, however, liable to be excited to over-action, and that effect is uniformly followed by a state of relaxation and debility, which is perhaps one of the most universal and important principles in pathology. The nature and influence of some of the causes which tend to increase or diminish the action of different organs, will be considered in the succeeding chapters.

One circumstance, however, deserves to be noticed before I conclude this section, which must certainly give additional weight and interest to the law I have endeavoured to deduce,—that mobility and perpetuity of ac-

tion are generally in an inverse ratio to each other, which is, that this principle is not confined to the muscular system, but extends likewise to the brain or organ of mind, which is governed by laws obviously analogous to those of motion. Thus daily experience evinces, that versatility of mind and liveliness of fancy are rarely combined with great powers of abstraction and strength of reasoning; and few are ignorant how much habits of deep research and profound thinking are unfavourable to brilliancy of imagination and fertility of invention. Females who have generally more mobility of fibre, have also, in a more eminent degree, the corresponding attributes of mind, namely, quickness of apprehension, vivacity of imagination, warmth of feeling and mobility of temper. Men, on the other hand, who have more tone and vigour of fibre, are more remarkable for strength of judgment, power of application, firmness and equanimity of mind.

Without going so far as to assert that these are incompatible with each other, we may safely admit, that the one or the other appears naturally to predominate; and although both may admit of improvement to a certain extent, yet as the one cannot be cultivated in a great degree without partially

neglecting the other, to arrive at excellence in both, if attainable, requires a degree of vigour of mind and energy of character with which very few are endowed.

I proceed next to inquire more particularly into the connexion between sensation and motion, and the reason of the phenomena attending corporeal and mental impressions.

## CHAP. III.

# THE CONNEXION

BETWEEN

# Sensation & Motion.

## SECT. I.

# INFLUENCE OF PHYSICAL IMPRESSIONS.

Impressions distinguished into Physical and Moral.——The Reality of Inconscious Feeling, how proved.——Inquiry into the Laws of Physical Impressions.——Pain, internal to Organs, increases their Contraction; external, causes their Relaxation.——Probable Cause of this.——Inordinate Contraction followed by Relaxation.——Pleasurable Impressions cause direct Relaxation.——Organic Sympathy.——Its Nature and Cause inquired into.——Similarity of Structure, Feeling, and Action, the chief Causes of rapid Participation in Change of Function.——The Influence of Continuity of Connexion considered.——How Participation of Organs, that want these Circumstances, is produced.——Important Law, deduced from Experiment, that Change of Action in Voluntary Organs is communicated through the Medium of the Nerves of Voluntary Motion; but Change of Circulation through the Medium of Vessels alone.——Why the Heart and Brain first participate in altered Circulation.——All Sympathy ultimately referable to Nerves; but the Structure of the Parts on which they expand, and not the Connexion of larger Branches, regulates the Phenomena.

THE animal frame, considered under its two-fold relation to the external world, and to its own internal economy, is subject to the action of two classes of impressions; one of which may be said to act upon the mind, and the other upon the body.

Under the influence of these external impressions, the internal and habitual feelings of the organs seem liable to be obscured by a stronger impression from without, as two impressions cannot be equally felt at the same time in the same part. But as every vital motion results from a feeling excited, change of feeling, as might naturally be expected, induces change of action.

The influence of external impressions will be considered, in relation to the organs affected, (namely, the brain or the nervous system,) under the separate heads of moral and physical impressions.

To the class of moral feelings belongs every mental perception that produces an association of ideas; a faculty which is, to a certain extent, under the dominion of the will, but often ceases to be, if excited by an impression too sudden and too powerful. Hence the passions, which are the most powerful of moral feelings, often gain the ascendancy over reason.

To corporeal feelings belong all those which arise from impressions acting physically upon the body; exciting action in the involuntary organs, and not necessarily attended with mental perception; the nature and influence of which I propose first to investigate.

It is true that in this inquiry, as mental perception does not always attend the impressions, their existence is sometimes only an inference, and in reasoning upon their effects analogy is often our only guide. But when we find painful impressions uniformly productive of an effort of resistance, and when lesion of the organ proves a cause to have been applied capable of exciting pain, could the mind perceive it, we seem almost warranted in concluding, that the effort of resistance which immediately followed its application, was the effect of the feeling produced in the part, although the mind received no cognizance of the impression. These efforts are not, however, to be regarded, as Stahl and his followers contended, as the acts of an intelligent principle residing within us, controuling all the functions, averting present, and anticipating future evils; but as the result of general properties with which the Creator has endowed living matter; in consequence of which it yields to what is grateful, and resists what is painful. Sometimes these efforts of resistance are themselves productive of more injury to the animal economy, than the causes which give rise to them; and the art of physic is as often directed to the means of moderating the one, as of removing the other.

In a complicated piece of mechanism like the animal frame, of which every part is adjusted and balanced with the nicest accuracy, no material change in the function of one class of organs can be induced without some general derangement of the rest; and most of the diseases incidental to man proceed from local disturbances, too trivial perhaps in the first instance to attract attention, or too transient to become objects of medical treatment.

From the diversity of structure and function of different organs, various consequences result from painful impressions, according to the part to which they are applied.

In the organs subject to the mind, reason assists in determining the mode of resistance, but involuntary organs are governed by laws more simple and general; and although the mind has often a limited influence over them, and sometimes assists their efforts by calling in the co-operation of parts more under her controul, as in the natural evacuations; yet by a careful examination of the phenomena, when divested of this combined agency, we may trace the effects of painful impressions on involuntary organs up to a few general principles.

# PAIN.

In vascular organs the effects of painful irritation seem reducible to these two laws,—that, irritation when internal excites increased contraction, and when external suspends or diminishes it.

After illustrating this curious fact by examples, we may attempt to account for these opposite effects resulting from causes apparently similar.—The following instances may serve to illustrate the effects of internal irritation:

In the stomach, vomiting is the usual consequence of any displeasing impression on the internal surface of that organ, and consists in increased efforts of contraction in the circular fibres surrounding it, assisted by the co-operation of other parts more immediately under the controul of the will, as the diaphragm and abdominal muscles, symphathetically brought into action, and made to contribute to the expulsion of the offending cause. In the intestines, unusual irritation is productive of diarrhæa, which chiefly arises from increased efforts of contraction in the fibres surrounding this canal. In the arterial

system, undue irritation is also productive of increased action, and quickened circulation is the consequence; a fact which is generally admitted, and indeed cannot be doubted, although many instances of quickened circulation are perhaps erroneously ascribed to internal irritation. In the capillary system, which possesses, as I have attempted to prove, a more limited range of action, any alteration in the degree of contraction is productive of a corresponding change in the functions of secretion and excretion, animal heat and sensibility; and (as I hope satisfactorily to prove hereafter) the presence of an irritating cause, inducing inordinate contraction in these minute vessels, is the immediate cause of those symptoms which constitute the cold fit of fever. In the sphincters and pores, immoderate distension, the species of irritation of which they appear to be most susceptible, induces (as stated in the last chapter) a powerful and obstinate constriction; and other causes of internal irritation can hardly arrive at these organs, from the previous constriction of the vessels themselves.

Increased contraction appears then to be the general effect produced by irritation, internal to vascular organs: that which is external, on the contrary, seems to suspend or

diminish their contractions, as appears from the following circumstances:

Blisters, applied to the stomach, frequently assist in allaying vomiting;—the same means often give evident relief in cholic, or spasmodic contractions of the bowels, when applied to the abdomen. If unusual irritation be applied in any way to the surface of the body, mechanically as by rubbing or scratching, or physically as by rubefacients or blisters, the immediate consequence is an increased determination of blood to the part. Now this congestion can only arise from one of two causes, namely, increased impulse in the blood, or diminished resistance in the vessels. But increased impulse in the blood cannot induce local congestion without a local cause; and if vessels be over-distended, their resistance must be less than the cause distending them. The resistance of the small vessels being rendered relatively weaker, must then be the ultimate cause of congestion; but the following consideration renders it probable that their relaxation is the primary cause of their over-distension, resulting from the general principle already stated—that two impressions cannot be felt and corresponded to at the same time in the same part.

The vessels contract when distended by the blood, in consequence of their feeling distension; but experience shews, in sensible organs, that two impressions cannot be felt at the same time in the same part; and we have more than analogy to support us in the inference, that the same law prevails in parts less capable of exciting the mental perception of pain; thus in the stomach, an impression that excites nausea is effaced by another more powerful and less disagreeable; and in the intestines, the irritation exciting diarrhæa is often effaced or suspended by the exhibition of a stronger stimulus. On the same principle, then, the usual impression of the blood may be effaced by the unusual and more powerful impression of external irritation, and consequently the contractions which depend upon the internal impression will be diminished or suspended also. But the contraction of the vessels being locally diminished, while the general impulse of the blood remains unimpaired, a congestion in the part will naturally follow; an effect which derives no explanation from the phrase increased action of vessels. General fever from local irritation no doubt aggravates the local inflammation; but this succeeding to, and not

preceding it, must be the consequence, and not the cause.

That the congestion produced by rubefacients arises from the external irritation they excite, and not from physical changes produced on the vessels of the part, appears from the influence of a blister being circumscribed to the spot where it is applied, but penetrating through parts of various structure, in a direction centrical to that spot. Thus I have been informed by a respectable surgeon, that he found, on opening the cranium of a patient who had died after a blister had been recently applied, an inflamed mark, exactly corresponding in shape and size to the external mark of the blister, which penetrated the scalp, the cranium, and was distinctly visible on the dura mater; an effect which could not result from the physical influence of the blister penetrating through parts of different structure, and protected by intervening bone, but may be easily conceived to arise from the external feeling effacing that which is internal, and thereby suspending the action of vessels, its influence extending, as might naturally be expected, in a direction centrical or perpendicular to the place of its application.

There is reason to suppose then, that

the general law of two impressions not being equally perceived at the same time in the same part, causes opposite effects to result from external and internal irritation of the vascular system.

We now come to an universal law in the animal economy—that over-action cannot be long kept up in any organ without producing subsequent relaxation; the secondary are, therefore, the reverse of the primary effects of internal irritation, namely, instead of increased contraction, relaxation of the organ; as illustrated by the following instances:

An emetic leaves the tone of the stomach somewhat impaired, and weakens, for a time, the powers of digestion. The exhibition of an active purgative impairs that of the intestines, and a degree of constipation usually prevails for a short time after its operation.—Increased action in the arteries, whether caused by active exertion or stimulant liquors, subsequently induces retarded circulation and disposes to sleep. Constriction in the capillaries, which constitutes the cold fit of fever, is uniformly followed by a state of relaxation, which will hereafter be shewn to constitute the chief cause of the subsequent hot fit. Suppression of urine in hysteria, which is often proved by the fruitless introduction of the catheter

to originate in the kidneys and not in the bladder, is generally followed by secretion remarkably copious, indicating previous constriction, subsequent relaxation either of the papillæ or uriniferous tubes. The thin watery secretion from the nose, on exposure to cold, indicating increased contraction of the secreting vessels of the mucous membrane, with attendant relaxation of the sphincters, (for reasons given in the preceding chapter,) is often followed by a sense of heat and fulness, with suppressed secretion, indicating relaxation of the same vessels, and constriction of their sphincters. Exposure to cold and wet is often productive of dropsy of the lower extremities in women employed in washing linen in cold cellars; and probably arises from previous constriction and subsequent relaxation of the exhalents of the cellular membrane causing increased effusion. The cartilages and ligaments of the joints (as Morgagni observes in treating of the gout) are particularly liable to be affected by cold for want of a muscular covering to protect them, and probably on this account they are most subject to rheumatic affections, consisting in inflammation from loss of tone in the vessels of these parts caused by previous constric-

tion, and then sudden relaxation from exposure to heat; for alternations of heat and cold are more likely to produce inflammations, than cold long continued, but gradually removed.

In short we find that inordinate action, by whatever cause excited, and in whatever organ, produces subsequent relaxation; and if too long continued, predisposes to inflammatory affections, or other symptoms analogous to them. The subsequent are then directly opposite to the primary effects of internal irritation.

We come next to the examination of the effects of pleasurable impressions on the organs of motion, and particularly on the vascular system.

## PLEASURE.

From pleasurable impressions contrary effects to those of pain might naturally be expected; their influence being grateful, no effort of resistance would be looked for; nor is contraction indicated by the symptoms, but rather an opposite state, namely, a gentle relaxtion, as the following instances illustrate:

The grateful impression of food excites no

resistance from the stomach; but that organ gradually relaxes to receive it, until a degree of repletion is induced, which admits of no farther addition without becoming painful. The pleasing impression in the mouth gently relaxes the secreting vessels and salivary ducts, and thereby augments the flow of saliva in proportion to the quantity of food taken. Gentle friction often assists, by the grateful sensation it produces, in removing spasms from the muscles of voluntary motion. A strong sense of pleasure induces a general relaxation both of the muscular and vascular system. The pleasing sensation produced by the infant at the breast gently relaxes the capillary vessels, and thus increases the secretion of milk.

The influence of pleasing impressions internal to the sanguiferous system scarcely appears to admit of illustration. As the blood alone comes in contact with it, and as any change in that fluid causes symptoms of irritation, it appears probable that every other fluid is in a greater or less degree unnatural and irritating to the vessels. Accordingly a slight shivering is often perceptible about the period when the chyle is supposed to enter the blood; and the succeeding heat, indicating subsequent relaxation of the capil-

laries, is still more conspicuous in the hectic flush that follows.

The increased secretion from every organ with which the ingesta come in contact as they pass through the different processes of assimilation, seems either to arise from the novelty of the impression external to the ducts and secreting vessels, or to the grateful effect it produces.

As the most important general changes of function continually arise from the operation of causes which, in respect to the immediate seat of their application, may be strictly termed local, our attention is now called to the examination of phenomena at once the most intricate and important to the pathological inquirer, which result from the participation of distant organs, or of the whole system in local change of function.

## ORGANIC SYMPATHY.

The participation of distant organs in local impressions is generally expressed by the term sympathy, which is, however, used in a sense so vague and indefinite, that the science of physiology would perhaps be bene-

fitted were the employment of it entirely rejected.

The phenomena referred to mental sympathy will be subsequently examined: those of organic sympathy will be the present subject of investigation.

A few examples will best illustrate the nature of the phenomena ascribed to the principle of sympathy, and the indefinite meaning attached to this term.

To sympathy are referred, sensations felt in one part from impressions made upon another; as the tickling in the throat, and cough, proceeding from ulceration in the lungs; itching of the nose from worms in the intestines; two cases apparently analogous, and fairly referable to the same cause, though its nature remain unknown.

To sympathy are also ascribed syncope or convulsions, from affection of the brain thro' impressions made upon the stomach, and altered action of the heart from the application of opium to the internal surface.

The two last belong to the phenomena of altered motion, the former to those of altered sensation; the analogy is, therefore, less obvious, and the cause of each being unknown, we are hardly warranted in assuming that it must be the same in both.

If strictly inquired into, the term sympathy will be found sometimes to imply an ultimate fact, without any reference to the cause; and sometimes, used in a more definite sense, it is meant to express a supposed community of feeling from nervous connexion between parts remote from each other, and different in structure and function.

To the former acceptation there seems to be no farther objection than its tendency to damp the ardour of inquiry by the semblance of an explanation, which it does not afford. To the latter a more weighty objection may be urged, as it involves the assumption of a very dubious principle. In either sense, therefore, its use appears objectionable; and it is perhaps desirable that it were banished entirely from physiological reasoning.

The subsequent inquiry is not supposed to remove every difficuly attending this subject, or to explain all the phenomena referred to organic sympathy; but it may perhaps contribute something towards rendering our ideas a little more definite respecting the cause and manner in which general derangement arises from local impressions, and may help to prevent some of the ambiguity attending the use of the term sympathy.

In conformity with the plan hitherto pur-

sued, the reader will be made acquainted with the inferences deduced before the arguments are detailed, or the experiments related from which they are drawn, that he may more readily perceive the connexion between them, and more easily detect any fallacy in the reasoning.

These experiments were none of them made by the author of this treatise; but they are certainly not the less satisfactory on that account. As they were made by different persons, at different times, and with different views, and diversified in a variety of ways, no reasonable objection can be urged against their accuracy. The most important were made upon frogs, as no other animals could be procured sufficiently tenacious of life to admit of the removal of the brain and heart without immediately suspending animation; frogs living some hours after the brain and heart are destroyed.

The substance chiefly employed was opium; but it is remarked by most of the experimenters, that this drug appears to have no peculiar influence on frogs different from its action on other animals, so that no fair objection can be urged on this account; and we may safely venture to conclude, that the general laws of life are essentially the same

in all animals, although modified by circumstances, such as the brain in some, and the ganglia in others, contributing more largely to the performance of functions immediately subservient to the support of life.

The first inference to be deduced from the phenomena of this supposed sympathy is—

That the existence of a community of feeling exclusively enjoyed between any two distant organs of different structure is highly questionable, as the tendency of one to participate in the affections of another is continually varying from accidental circumstances. Thus exposure of the lower extremities to cold and wet may produce in one person catarrh, in another pleurisy, in a third rheumatism, in a fourth gout, in a fifth dropsy, in a sixth asthma, in a seventh diarrhæa, or other effects according to the period of life, and peculiarity of constitution; no exclusive sympathy prevailing between the organ ultimately affected and the original seat of the impression.

The communication of sympathetic change of function is usually ascribed to nervous connexion; and as feeling and motion immediately depend upon nerves, they may no doubt be instrumental to its production; but

all parts of the body are connected by nerves, and no reason is thus assigned why one part should be more affected than another.

Peculiarity of constitution, rendering one organ more delicate than another, may throw some light on this point; and the modifying influence of age resolves itself into the same principle, which may be collected from the doctrines of Cullen, who points out the reason why different organs are more susceptible of derangement about the period when they arrive at maturity. Thus the head is most liable to be affected during infancy, the throat in childhood, the lungs about the age of puberty, the abdominal viscera at a more advanced period, and the extremities in the decline of life. Dr. Cullen explains the cause of this by supposing the successive arrival of each organ, at a state of maturity, to be attended with a change in the condition of its vessels, which lessens the determination of blood to that part. Prior to this period he conceives the resistance opposed to the blood to be relatively less in that than in other parts, until at length the increasing density gradually preventing further distension and accretion, offers greater resistance, lessens the relative quantity of blood sent to the part,

and finally augments its afflux to parts where less resistance is opposed.

But we certainly have some organs which are naturally more liable at all times to general participation from local affections, according to that which is primarily affected: and we are indebted to Bichât for enlarging our views very considerably, with respect to the nature and causes of this participation.

Of these, the most important are similarity of structure and community of function: thus we have affections of the muscles of locomotion—of the serous and mucous membranes—of the glandular system—of the bones—of the ligaments and tendons, without manifest participation of other organs.

Inflammation of the pleura may exist to a considerable degree without affecting the intercostal muscles which are in close contact, but of different organization. Rheumatic affections may extend from joint to joint without affecting intermediate organs of different structure. Inflammation of the mucous membrane may extend along the whole surface of the intestines without affecting the serous membrane which is almost in close contact with it. Glandular swelling may proceed from one part to another without participation of other organs. Gouty metastasis, dropsical

deposition, altered secretions, are all instances of changes affecting a particular class of organs exclusively or more than others, and sufficiently establish the influence of similarity of structure and community of function, in augmenting the tendency of organs to participate in the affections of others of the same class.

Why impressions received should be more uniformly felt through parts having similarity of structure, if we cannot explain, we may partly conceive from the principles deduced in a former part of this inquiry; in which it was shewn that parts, similar in structure, have each an exclusive mode of feeling, the structure of the organ modifying the impression received.

Why change of action should be more rapidly communicated to parts having similarity of structure and community of function, may also be partly conceived from principles previously deduced; by which it appears, that change of feeling causes change of function, the action of all vital organs depending upon the feelings excited.

But there is yet another circumstance equally manifest which demands our attention, and this is the influence of continuity of connexion in communicating changes; the

importance of which will appear from the following considerations:

The pleura of one side has a connexion by the mediastinum with that of the other, beyond which its affections do not readily extend to other serous membranes disjoined, though similar in structure, as to the peritoneum. The mucous membrane has a continued connexion extending over the whole internal surface, though partially disjoined, and its affections are more readily communicated to the parts immediately connected with that inflamed, as from the larynx to the the lungs, or from the œsophagus to the stomach, than to parts more contiguous but partially separated, as from the larynx to the œsophagus. Cutaneous eruptions shew still more remarkably the influence of continuity of connexion, in the rapid progress they make over the whole surface of the body. Erythematic inflammation and dropsical effusion illustrate the same point, and all shew the importance of continuity of connexion.

But we have instances of affections extending from one organ to another which appears to have neither continuity of connexion, similarity of feeling, nor community of function; as from the surface to the stomach, from the stomach to the brain, and from the brain

to the heart; and to refer these affections to nervous connexion in general, is, as before stated, affording no explanation.

This then is a point which remains to be ascertained; and from the arguments to be adduced, and the experiments to be detailed, the following inferences appear to be warranted: —That change of action in organs of voluntary motion, is communicated through the medium of nerves of voluntary motion. That change in the circulation of one organ transferred or extended to that of another, is communicated through the medium of the organs of circulation.

Of course it should appear, that convulsions of voluntary muscles from impressions on the stomach, must depend upon changes previously induced in the sensorium, which reacts upon the organs of locomotion, through the nerves of voluntary motion. The previous changes induced in the sensorium itself, we shall hereafter find to be changes of circulation; these therefore should be communicated along connecting vessels. When the action of the heart is altered by impressions on the stomach or surface, this being an involuntary organ, its altered action should not depend on changes previously induced in the sensorium, but upon some other cause; which we shall

hereafter find to be an altered condition of the vessels, modifying the impulse given to the blood going to the heart, and the resistance opposed to that coming from it.

That the action of the heart is liable to be affected by change in the impulse of the blood sent to it, and the resistance met with by that coming from it, may be inferred from the familiar effects of bodily exertion and of exposure to heat or cold, in altering the circulation, but the extent of this influence has never yet been fully developed.

That the action of the heart may be affected by impressions on the stomach, independently of the influence of the brain and cerebral nerves, appears from the following experiments, to be found in the Appendix to Dr. Wilson's Treatise on febrile diseases:

Fontana having destroyed the brain and spinal marrow in twenty-four frogs, introduced opium into their stomachs, and into those of an equal number with the brain entire.

These animals, which otherwise live a considerable time after the brain and spinal marrow are destroyed, died in a few minutes, the action of the heart being equally retarded in those with the brain destroyed, and in those with it entire.

Dr. Wilson confirmed the same experiments, which shew that the brain and connecting nerves are not essential to the participation of the heart in impressions on the stomach. The experiments were repeated by Dr. Wilson with the same results, by injecting a solution of opium into the cavity of the abdomen; the participation of the heart, therefore, does not depend upon any exclusive nervous sympathy with the stomach.

The influence of opium taken into the stomach does not require its absorption and direct application to the part indirectly affected, as appears from its occurrence after the circulation is suspended, and from the suddenness of the effect produced.

If the participation of distant parts in the action of opium upon the stomach depended upon the direct conveyance of the deleterious impression to these parts, through the medium of connecting nerves, we should expect to find their degree of participation proportioned to the strength of the solution employed; but the fact is otherwise.

Dr. Wilson found, that the loss of irritability in voluntary muscles bore a relation to the force and frequency of convulsions that preceded death, and not to the strength of the poison; and even observed as a singular para-

dox, that a weaker solution that caused a lingering death preceded by more frequent convulsions, exhausted their irritability more completely than a stronger solution, causing immediate death preceded by less frequent convulsions. He also found the same effect to result from augmenting the frequency of the convulsions by mechanical irritation previous to death, the solution remaining the same.

This circumstance then naturally suggests, that the power of the heart may be also exhausted by the inordinate efforts it is compelled to make, if the action of the vessels be so altered as to augment the impulse of the blood going to it, and the resistance to that coming from it, to a degree greater than it is able to overcome. And this supposition derives support from the experiments of Bichât, and some recently laid before the Royal Society by Mr. Brodie, who found its irritability much impaired or totally lost, when on dissection it appeared gorged with blood and overdistended, but unimpaired or retained to a considerable extent, when it was found comparatively empty. On attempting to renew its action by artificial respiration, its suspension was found to arise from want of power to act in the former case, and from want of blood to excite it to action in the latter.

The function of the brain depends, as well as that of the heart, upon the force and quantity of the blood sent to it; it appears, then, that important change of function in this organ may also be induced through the medium of the vessels, from impressions made upon those of the stomach causing a general participation, as the whole vascular system participates when the feet are immersed in cold or hot water.

That the changes in the condition of the brain which give rise to syncope or convulsions from impressions on the stomach have their immediate seat in the vessels, appears to be demonstrated by the following experiments:

Monro and Fontana performed experiments similar to the following, with nearly the same results; but Dr. Wilson appears to have repeated them with more accuracy, and to have obviated several objections.

He cut out the hearts of twenty-four frogs, and injected a solution of opium into the stomach of some, and abdomen of others, and found them all affected in the following manner, the approach of death being accelerated in proportion to the quantity of solution injected:—a languor came on, from which they recovered in a few minutes; but

it gradually returned, and they all died without the least perceptible struggle or convulsion.

Now when death was induced by opium injected into the stomach, the heart remaining entire, it was always preceded by convulsions; whereas the removal of the heart prevented this effect, a gradual languor and sinking with little fluctuation preceding death.

But if convulsions depend upon the deleterious impression made upon the nerves of the stomach being equally participated by the brain from sympathy through the medium of nervous connexion, why should the removal of the heart prevent their occurrence, or its operation be at all necessary to their production?

If, on the contrary, they depend upon an altered circulation, as we shall hereafter find, we may easily conceive how the heart may co-operate along with an altered state of the vessels themselves to produce either an excessive abstraction of blood, or an immoderate degree of congestion in the sensorium; and how the removal of the heart may prevent the occurrence of convulsions altogether.

The influence of the heart in contributing to produce convulsions, is further confirmed by the result of Mr. Brodie's experiments,

before alluded to, who generally found the heart in a state of action when convulsions to any extent occurred previous to death; but gorged with blood and apparently overpowered when syncope alone preceded death. In one case (Exp. 12) convulsions occurred, although the head was removed; but the spine, which appears more directly instrumental to motion of the limbs, remained entire, and the means employed to keep up respiration would help to promote congestion in it. When circulation was stopped, by a ligature thrown round the vessels at the base of the heart, the convulsions began to decline.

Demonstration in physiological reasoning is less frequently obtained than experimenters are willing to believe, nor can it always be reasonably expected; but if we affix to probabilities a degree of confidence apportioned to the strength of the evidence on which they rest, and are always willing to withdraw it on the appearance of stronger arguments in favour of an opposite conclusion, we may safely proceed upon the premises we obtain.

For the present then we may venture to allege, that the strongest probability prevails in favour of the opinion, that important change of function both in the heart and the brain may be induced through the medium of al-

tered circulation, without the necessity of resorting to the supposition of a community of feeling through nervous connexion, between organs that have neither similarity of structure, continuity of connexion, nor community of function.

But if we now consider, that all these circumstances, so essential as before shewn to a rapid participation of feeling and action—viz. similarity of structure, continuity of connexion, and community of function—are possessed in an eminent degree by the blood-vessels going from one organ to another; and that the important derangements induced in these organs have their immediate seat in the circulation, as the various kinds of inflammation, altered secretion, dropsical deposition, cutaneous eruptions, glandular swelling, general fever,* and, as we shall shortly find, intoxication, syncope, and convulsions; and if we further consider that the causes inducing these affections are all directly applied, either internally or externally, to the vascular system;—we can hardly withhold our assent to the proposition originally stated, that these changes are directly conveyed from one part of the vascular system to another, through the medium of connecting vessels, and not by the large branches of nerves com-

municating between organs dissimilar in structure, feeling and function.

That vascular connexion is not however the sole cause of change of action affecting distant parts from local impressions, appears from the following experiments :

Whytt, Fontana, Monro, Wilson, and others, found, that cutting the nerves communicating between the brain and any of the limbs subject to its controul, previous to the injection of opium into the stomach, prevented convulsions from taking place in that limb; and Wilson found that limb to retain its irritability in a more eminent degree than others after death.

Thus convulsions of the limbs appear to depend upon previous changes in the brain acting through the nerves of voluntary motion ; but the previous changes in the condition of the brain from poisons applied to the limbs seem again not to be communicated to the brain through the medium of the same nerves, as the following experiment shews :

Mr. Brodie found, that cutting the nerves leading to the brain did not prevent the participation of this organ in the impression of poison applied to a wound made in the limb ; but on the contrary, this participation was prevented by throwing a ligature round the

limb, including every other part, but leaving out the connecting nerves.

To explain the specific action of poisons is not my object; many important principles are yet to be ascertained before we can arrive at this knowledge; but there does not appear any material objection to the principles deduced, to be drawn from any of the experiments here alluded to, but what will be sufficiently obviated in the subsequent part of this inquiry.

The observations already offered relate chiefly to the participation of distant parts in altered action; but it is not improbable, that altered sensation may in some measure depend upon similar causes.

Thus the itching of the nose from worms in the intestines may arise from a change of condition in the minute vessels of the mucous membrane extending along the surface of similar organization to the fauces and nose. And as the sensibility of all organs depends upon the condition of the minute vessels, this may be the cause of their increased susceptibility, and give rise to the itching produced, which is the mode of feeling exclusively confined to that part exposed to the air.

This change of sensibility is not confined

to the extremity of the membrane, as the cough, also excited by worms in the intestines, sufficiently proves, shewing the altered susceptibility to continue along the whole course of the membrane, though it excites sensation only in those parts exposed to the impression of external causes, and supplied with cerebral nerves.

Besides the various circumstances before alleged to render one organ more susceptible of impression from altered circulation at times than another, as organic weakness constitutionally or casually induced, some organs are naturally more sensible of general changes in the vascular system than others.

The most conspicuous in this respect are the heart and the brain,—the former from its immediate dependence upon the vessels for the stimulus of distension that excites it to action; and the latter from its receiving the blood sooner, in greater abundance and with greater force than other organs, and likewise from its being surrounded and confined on every side by bone, and therefore more sensible of any change in the degree of pressure it undergoes; and lastly, from its being the organ of mind or the seat of mental perception.

We may also perceive a final cause why

this organ, so essential to every animal function, should have the earliest notice of changes that may be prejudicial to the animal economy, being the only organ endowed with reason to guide it in the endeavour to avoid or remove them.

A final cause is no less obvious why the heart, an organ whose regular and uniform action is so essential to the healthy performance of every organic function, should be more exempt from the direct influence of local impressions than other parts, as it would otherwise be subject to continual derangement from external causes.

If it be alleged that the preceding views ascribe too much influence to the vascular and too little to the nervous system, let the following circumstance be considered, and the objection is answered:

As all parts owe their faculty of feeling and moving to their nerves, so the blood-vessels owe theirs also to the minute nerves pervading their structure and entering into their substance; and to these must be ascribed their general participation in extensive local changes, and not to the larger branches, communicating with the brain, or connecting organs dissimilar in structure, feeling, and function. And thus the nerves are still to be regarded

as the ultimate seat of sympathy, both of sensation and motion, of voluntary and involuntary organs. But from the structure and organization of the parts on which they are distributed, they appear to derive the most important peculiarities that characterize them.

These then are the points that claim the attention of the physiologist, as calculated to enlarge his views of the animal economy, and to afford a clearer insight into the nature and cause of diseases.

We next proceed to examine the connexion between the passions and the bodily economy, or the influence of moral feelings.

## SECT. II.

## INFLUENCE OF MORAL IMPRESSIONS.

ANALOGY between the Laws governing the mental and bodily Functions.—Passions arise out of Sensations.—Attention defined.——Its Power of modifying the Influence of sensible Impressions illustrated.——Organs most subject to Mental Influence.——Abstraction; its Nature and Influence illustrated.——Important Influence of Attention over the Functions of Voluntary Association, Memory, Judgment, Imagination, and Invention.——Fear; supposed sympathy between the Heart and Brain inadequate to explain its Effects.——Its moral Nature and physical Effects inquired into.——Anxiety; a modification of Fear and Hope.—Curious Analogy between the Effects of real Pain, imaginary Pain, and apprehended Pain.——Hope; its moral Nature and physical Effects.——Grief; peculiarity of its moral Nature.——Symptoms enumerated; Cause of Sighing and Sobbing; Cause of Tears; Explanation of the primary Action of Grief attempted.——Joy; analogous to Hope and Pleasure.——Anger; its affinity to Grief, and the Importance of this.——Its Symptoms enumerated and explained.——Why the Pulse is stronger in Anger than in Grief.——Instance of the fatal Effects of Anger and Grief.——Pity analogous to Grief. Hatred allied to Anger.——Love; often confounded with other Passions; an unequivocal Instance selected.——Definition attempted.——Origin inquired into.——Varieties from the Dispositions of Individuals; physical Effects stated, and their Diversity accounted for.

BY moral feelings, I mean to imply every mental emotion arising from and excited by an association of ideas. The nature of ideas cannot be explained without accounting for

perception itself, as ideas appear to consist in the perception of changes in the brain ; the nature of which is also unknown.

These changes may either arise from impressions received through the medium of the senses, or may recur from impressions formerly received in that way. The function of the brain in receiving impressions is passive and involuntary; but the faculty of recalling, combining and comparing them, is of an active nature, and to a certain extent under the controul of the will, and governed by laws obviously analogous to those of other voluntary functions.

The analogy between the laws governing the brain and other bodily organs, appears in the following circumstances :

Their functions are alike attended with a painful sensation when exerted to excess ; and over-exertion is followed by a state of relaxation and debility, whereas a restoration of their powers is derived from rest and sleep; and a number of concurring circumstances abundantly prove, that the mental faculty, like every other, immediately depends upon the physical state of the organ : thus whatever causes a change in the circulation of the brain induces a temporary change in the powers

of mind ;—intoxication produces confusion of thought ; fever causes delirium ; and palsy is frequently attended with loss of memory. Every voluntary function is frequently exerted without any conscious effort on the part of the will. Thus in conversation the eyelids are kept raised, the lower jaw suspended, the head supported, the body poised, and perhaps the limbs exerted in walking, while the only effort we are conscious of, is probably that of the organs of mind and speech requisite to the conversation we are maintaining. In the same manner the powers of association are continually exerted from the influence of casual impressions without any obvious exertion of the will. All organs are liable from excessive or painful impressions to be excited to inordinate contractions, which the will is for a time unable to controul ; so the organ of mind may be excited to inordinate action by a mental impression if too sudden or too powerful, and of this nature is the influence of the passions the strongest of moral feelings. The changes produced by physical impressions chiefly affect the state of circulation in the organ acted upon, and the same effect will be found to result from moral impressions acting upon the

brain, sometimes productive of congestion of blood in its minute vessels, as indicated by derangement of function, head-ache, throbbing of the temporal arteries, flushing of the face and redness of the eyes, which receive their blood directly from the centre of the brain. The local derangement induced in the circulation of the brain cannot indeed, like that arising from physical impressions on external organs, be rendered obvious to the senses, but its existence may be inferred from the general derangement visible in the vessels leading from this organ, and the nature of the internal changes may with tolerable certainty be ascertained by a careful analysis of the symptoms which these changes induce.

As the passions arise out of the sensations, their nature and influence will receive much light from the analogy subsisting between them; and our inquiry into the nature and effects of the passions on the bodily economy, will derive considerable illustration, from the previous examination of the influence of simple attention in altering the faculty of sensation; and this investigation will serve at the same time to elucidate the nature and cause of various phenomena ascribed to mental sympathy; a term implying an occult cause, rather than furnishing an explanation.

## ATTENTION.

The nature of attention requires little illustration, an appeal to consciousness at once informing us what it means, and the most acute metaphysician cannot, I apprehend, go much farther; but as a definition may be given which, without any deviation from truth, will assist in placing it in that point of view most favorable to the explanation of its effects, I shall adopt the following:

Attention may be regarded as that faculty by which the mind dwells upon a perception, so as to augment its consciousness of it.

From this view of the nature of attention we see at once its application to physiology, in the power it possesses of augmenting the perception, and consequently the effects of an idea or sensation.

Before I proceed to illustrate this fact by examples, it is necessary to observe, that its influence does not extend to all organs in an equal degree, those deriving their nerves directly from the brain being more immediately subject to it than those which derive them from ganglia; thus the organs of sense and the external surface are more con-

spicuously under its influence than internal organs; but from the remarkable sympathy that prevails throughout the vascular system, the nature and cause of which have been already inquired into, the changes produced in the one are rapidly communicated to the other, and any extensive partial change soon becomes general, as shewn by immersing the feet in hot or cold water, or the general glow of heat by taking any thing stimulant into the stomach. The following examples will both illustrate the power of increased attention in augmenting the effects of particular sensations and ideas, and likewise by the order in which they are given, shew what organs are most subject to mental influence.

Blushing in persons of irritable habit will often arise from thinking of it, or from being asked why they blush. Thinking of grateful food, or the sight of it, excites an increased secretion from the salivary glands. Looking at a person with inflamed eyes will frequently excite a transient redness or watering in the eyes of the beholder. Irritation in the larynx or the throat, too trifling to be felt or noticed, unless the attention be directed to it, often produces an inclination to cough on hearing another person do it. The sense of weariness in the muscles that support the lower jaw, which

comes on at the approach of sleep, and induces yawning, may at any time be fancied, or brought on if the attention be directed to it by witnessing another person yawn. The flow of milk very frequently commences at the sight of the infant before it touches the breast of the mother. The propensity to micturation is often brought on by the thoughts of it; attention, involuntarily excited, increasing the perception of impressions which promote relaxation of the sphincters both of the bladder and rectum, namely, the perception of moderate internal pressure. The act of vomiting depends not only upon the altered action of the stomach, but also on the co-operation of the diaphragm and abdominal muscles, which are more under the controul of the mind; imagination has therefore considerable effect in promoting it, and the persuasion that some nauseating substance has been swallowed by mistake, or the smell of some drugs, is sufficient to excite it. The action of the heart is also frequently affected by mental emotions; but whether this arise from attention modifying the perception of its impressions, or from previous changes in the superficial vessels accelerating or retarding the afflux of blood to that organ, remains yet to be ascertained, and does not properly fall

under consideration at present. The influence of attention over the vessels terminating on the surface is often distinctly perceptible in the increasing moisture in the palm of the hand on approaching to take that of another person whom we wish not to perceive it, or in the augmented glow in the face with increased perspiration after dancing, if by accident we discover any one observing us, or feel conscious of appearing much overheated.

The effect of attention in aggravating the perception of pain is familiar to every one who has been afflicted with the head-ache, ear-ache, tooth-ache, or the sense of weariness in the limbs resembling rheumatism, and also in rheumatism itself in the chronic stage, and perhaps I might add, in every painful affection. But these being sufficient to illustrate its influence in augmenting the perception and effects of ideal or sensible impressions, I shall add a few examples of the influence of abstraction in diminishing those effects. Not indeed that this can be justly regarded as a peculiar and distinct faculty, as we have no direct power of diverting our attention from any idea or sensation; but the faculty of increasing our efforts of attention

to another object has indirectly the same effect as positive abstraction.

The influence of surprise, in checking a person on the point of sneezing, is familiar to every one; and the hiccough is suppressed in the same way. Let a cough be ever so troublesome, it seldom occurs when we are eating, the stronger impression on the œsophagus effacing the impression on the larynx, upon which probably depend the beneficial effects of sucking a lozenge. Instances of both head-ache and tooth-ache being relieved by the receipt of agreeable news, or the welcome arrival of an unexpected friend, are by no means uncommon; and a sudden alarm is stated to have checked the operation of an emetic, or stopped the paroxysm of an intermittent. A gentleman of my acquaintance very commonly had recourse to the chess board to alleviate the pains of the gout; and another friend informs me, that he found any thing that engaged his attention or excited an interest afford the greatest relief in attacks of asthma.

As mental diseases also become the subject of medical treatment, an acquaintance with the moral influence of attention, and the important share it has in the performance of the

mental functions, is essential to the physician as well as to the moral philosopher. When properly controuled, it lays the foundation for the improvement, as it in fact constitutes the basis, of every faculty of mind.

By directing this effort to particular impressions, and thus increasing their force, we are enabled to controul the train of ideas and acquire the power of voluntary association. By the same means we learn to recal or renew at pleasure former impressions, and cultivate the talent of memory. By augmenting the force of ideal above that of sensible impressions, we are enabled at will to abstract our minds from sensible objects and wander into the regions of fancy. By selecting particular ideas and dwelling upon them, we are enabled to compare them and observe the relation between them, and improve the judgment. And at length, after observing the apparent connexion between cause and effect, we learn by the aid of imagination and memory so to modify them, as to produce new results, and thereby acquire the talent of invention.

Thus attention properly employed constitutes the basis of voluntary association, memory, imagination, judgment and invention; but, like every other faculty, it is liable to

over-exertion and misapplication. When it is too often or too powerfully directed to particular conceptions, their impression frequently becomes so strong from habitual repetition, as to overcome the controul of the will, and deceive the judgment into a belief in their reality. Mere ideal impressions in this way acquire the force of actual sensations, and the suggestions of imagination are mistaken for sensible feelings: the hypochondriac experiences from a distempered mind sufferings like those of real bodily infirmity; and the maniac reasons, often with acuteness, from groundless premises or imaginary perceptions.

## FEAR.

The effects of the passions on the bodily economy are usually ascribed to their stimulant or sedative influence altering the action of the heart; and they have accordingly been divided into two classes, one of which is termed exhilarating, and the other depressing; the former being supposed to increase, and the latter to diminish the action of the heart and arteries.

Fear and grief belong to the class of de-

pressing, joy and hope to that of exhilarating passions; anger, hatred and revenge, as they also augment the force of circulation, are considered as analogous to the stimulant passions.

But a very little reflection will be sufficient to shew, that this attempt at generalization is no other than the usual resourse of setting aside a difficulty, instead of solving it.

In the first place, the fact that the action of the heart is primarily diminished by fear is itself very questionable, as violent palpitation often occurs amongst the first symptoms, which certainly indicates increased rather than impaired action in that organ. But if the fact were unquestionable, it could not be called an explanation of the symptoms, as the supposed sympathy between the brain and the heart, to which this effect is ascribed, is only the admission of an occult cause which leaves us as much as ever in the dark. But we have already seen strong reasons to doubt the existence of any community of feeling between parts dissimilar in structure and function; and likewise for concluding that the heart is of all organs least subject to cerebral influence.—That its action is changed under the influence of mental emotions is indisputable; but we may hereafter find from an analysis of the symptoms a sufficient explanation of this, on

principles more consistent with the general economy of the system.

Besides after all, if both the fact and the alleged sympathy were admitted, they would still be inadequate to account for the phenomena of fear. Diminished action of the heart may occasion a general paleness, cold sweat, and tremors, as we see in fainting and hæmorrhage, but it does not produce that excessive constriction of the surface and scalp, by which the hair, as it is said, stands on end, and tremors are excited that violently agitate the whole frame and cause the teeth to chatter, as in trismus or the cold fit of ague; and sometimes also involuntary evacuations take place. These are not explicable on any supposed sympathy between the brain and the heart; let us then turn our attention elsewhere and consider the brain, instead of the heart, the proper organ to receive mental impressions, and try to ascertain the mode in which it is affected by them.

Before we can explain the physical influence of fear, the first step is to acquire an adequate idea of its moral nature. One peculiarity attending fear and hope is, that they are both anticipations of future feelings; the former being the expectation of sufferance, the latter of enjoyment. The most usual motive

of fear is bodily pain, but the term is applied perhaps metaphorically to the apprehension of any suffering or privation, as loss of friends, of property or of reputation.

In the latter cases it becomes really anticipated grief, and accords with that passion in a great degree in its physical effects. In the former, its effects bear a remarkable coincidence with those of actual pain. Again, fear is seldom wholly divested of hope, and the fluctuations of each so modify the effects of both, that it is often impossible to trace their separate influence; thus fear takes away the strength, but a ray of hope restores and increases the powers of resistance, hence fear has been sometimes supposed to supply an unusual degree of muscular energy. To illustrate the effects of this passion, I shall select the most unexceptionable instance, and leave to others to trace the varieties that may arise from combinations of different emotions.

The anticipation of bodily pain I conceive to be the most literal acceptation of the term, and its effects on the bodily economy are the most unequivocal. Superstitious dread, or that terror which the vulgar feel, at the sight of what they suppose a supernatural appearance, is also an instance of similar corporeal effects to those I am about to describe, and

may either arise from what Darwin terms an associative action, by which parts that have once acquired a habit of action often exert it from causes very different from those which first induced it; or there may be a direct connexion between superstitious fear and the apprehension of evil, as appears very probable from its effects being greatly augmented by conscious guilt.

We may now state the symptoms induced, and then proceed to analyze them.

The effects of fear are first visible in the countenance; the blood flies from the face, the eyes become fixed, the teeth chatter, the voice is intercepted, all the limbs tremble or become paralized, the surface becomes constricted and bedewed with a cold sweat, an oppression is felt at the breast and often violent beating at the heart, urine and fœces are sometimes passed inconsciously; syncope, and in extreme cases sudden death is stated to have occurred.

If the cause be transient, its sudden removal is immediately followed by what may be termed the secondary symptoms. The blood rushes back to the face with unusual force, violent palpitation is felt at the heart and throbbing in every artery, increased heat with thirst and perhaps severe head-ache come

on, or if any organic weakness pre-exist, local derangement frequently follows; the nature of which depends upon a variety of circumstances. In one person it may give rise to a fit of gout, in another to an attack of jaundice, in a third to a fit of hysteria; if a predisposition to organic disease exist in the brain, in the heart, or the larger vessels, mania, epilepsy, apoplexy, aneurism, or sudden death may be the consequence, or a variety of effects according to the nature and degree of the exciting cause and the constitution of the person.

Reasoning from the symptoms, the brain is evidently the primary seat of the affection, both from its first appearing in parts contiguous, and from the nature of the cause, the brain alone being susceptible of mental impressions; and the nature of the symptoms clearly indicates, that the changes induced have their immediate seat in the vessels.

Thus the paleness of the face and shrinking of every vessel in the region of the head, with diminution or suspension of the faculties of mind, all indicate a change in the vessels, the function bearing a constant relation to the circulation of an organ. The same changes, as we have already seen, are liable to extend to other parts of the vascular system,

but first to those which are most under cerebral influence.

From the nature of the symptoms in other parts it is equally obvious, that they also have their seat in the vascular system; as the paleness, shrinking, diminished heat, and impaired faculty of feeling and motion; all which indicate diminished quantity of blood in the minute vessels, of the surface and muscles, as well as the brain.

We may next inquire into the cause of this absence of blood from the minute vessels, and one of two causes must be admitted: either the blood is not sent to the vessels as usual, or the vessels do not receive it as usual.

Now the occurrence of palpitation seems to prove, that there is no diminution, but probably an increase of action in the organs that impel the blood, and therefore we have no alternative but to admit, that the vessels are no longer in the usual state to receive it; or in other words, they must be excited to a greater degree of constriction, by which the blood is expelled out of them, and greater resistance offered to that flowing into them. The affinity between actual pain and fear, which is the anticipation of pain, has been already noticed, and this may in part illus-

trate the operation of the latter in also constricting the vessels. The mental impression of fear, or the anticipation of pain, operating on the vessels of the brain, in a manner analogous to actual pain in other vessels, excites them to increased contraction, and thus diminishing the afflux of blood to the organ, directly impairs its function; while the same changes of action being rapidly communicated to other parts of the vascular system, cause paleness, shrinking, and diminished faculty of feeling and motion over the whole body. But along with these we have often violent palpitation with sense of oppression at the chest, for which the most obvious cause that presents itself is the excessive accumulation of blood about the heart and large vessels, in consequence of its sudden expulsion from the smaller.

The secondary symptoms of fear follow as a natural consequence of the primary, the duration of these in some measure depending upon the degree and permanence of the exciting cause. The law formerly deduced, that over-action in every moving organ is liable to induce a subsequent relaxation, explains why an opposite state occurs as soon as the ex citing cause is removed; accordingly in the second stage the face is flushed, the surface

red and turgid, head-ache, thirst, and increased heat arise; all indicating over-distension of the minute vessels, which is produced partly by direct relaxation of the vessels themselves, and partly by the increased action of the heart and arteries, stimulated by the unusual quantity of blood thrown upon them.

In this stage, if any local or organic weakness prevail, congestion or inflammation will be most likely to occur where the power of resistance is least; and thus apoplexy, epilepsy, hysteria, jaundice, gout, or aneurism may be the consequence. If syncope occur, it is most probably always in the first stage, from expulsion of the blood from the brain; and diminished energy of that organ, causing a temporary paralysis, may produce the violent rigors and involuntary evacuation of urine and feces. And thus may all the phenomena of fear be accounted for from primary constriction and subsequent relaxation of the vessels of the brain.

Anxiety, which is a modification of fear combined with hope, produces also similar effects in a minor degree; at first paleness, tremor, clamminess of the surface with palpitation, subsequently increased heat, flushing of the face and pain of head. These effects may, from acquired habit, be induced by causes

not associated with the apprehension of bodily pain, and in very irritable habits not unfrequently occur without any obvious cause:—as the shivering of an ague first induced by marsh effluvia, may be afterwards brought back by an easterly wind.

From the foregoing arguments we are led to the conclusion, that the brain, and organs most amply supplied with cerebral nerves, are most liable to participate in mental impressions; and we are likewise led to infer, that actual pain, ideal pain, and apprehended pain, all operate on these organs in the same way.

## HOPE.

The moral nature of hope being opposite to that of fear, its physical effects are also the reverse of those produced by that passion.

Fear is the apprehension of suffering, which seems from the symptoms to induce a constriction of the vessels of the brain and surface, and through vascular sympathy probably of the whole capillary system. Hope, which is the expectation of pleasure, seems from the following symptoms to induce a moderate relaxation of vessels. The effects of hope are a general increase of sensibility and

mobility—a pleasing glow of warmth over the surface, and a general increase of health and alacrity, with a freer circulation and more regular performance of all the functions, animal and organic.

All these symptoms indicate a gentle relaxation of the capillary system, which facilitates the transit of the blood to and from the heart, rendering the pulse quicker and softer, the secretions more copious, increasing the animal heat and sensibility, and thus rendering the body more fit for receiving pleasurable impressions; whereas the constriction induced by fear is calculated to render it less susceptible of painful impressions, which may be regarded as the final cause of these changes. Were altered action of the heart alone capable of producing these effects on the secretions and excretions, we should be able to remove a number of diseases which have long baffled the skill of the physician; but daily experience declares, that the mental impressions of joy and hope have more influence in relieving affections that arise from altered or vitiated secretion, as dyspepsia, chlorosis, jaundice, &c. than all the powers of medicine combined; and when the mind labours under the influence of impressions that counteract their

effects, the most skilful treatment will often prove unavailing.

## GRIEF.

Fear and hope are both anticipations of future feelings, and therefore closely allied in their mode of operation with corporeal impressions. Grief is not of an anticipative, but of a retrospective nature, and is so far from having any connexion with bodily feelings, that it appears never to arise from them; the remembrance of pain producing an opposite effect to that of pain itself, so much so as often to be dwelt upon with pleasure; and the remembrance of past pleasure, if attended with no hope of return, being often productive of painful regret. This passion seems more exclusively of a moral nature, having no association with bodily feelings; of which it renders the mind insensible and regardless. Important changes in the circulation of the brain are indicated by the symptoms it induces, which I shall first state as faithfully as I am able, and then attempt to ascertain their cause.

The first symptoms of bodily participation in a paroxysm of grief are deep sighs and

interrupted respiration ; these are followed by a sense of weight or fulness in the head, which causes the hand to be instinctively carried to the forehead, where the oppression is chiefly felt ; flushing of the face, redness of the eyes and copious flow of tears often succeed, from which the head now obtains some relief ; and respiration, still interrupted with sobs, becomes somewhat more free ; the pulse, before unequal and intermitting, becomes now fuller, softer and more regular. If relief be not obtained by a flow of tears, which are sometimes suppressed in excessive grief, worse consequences may follow, as violent head-ache, convulsions, mania, or apoplexy, according to the circumstances of predisposing and exciting causes.

This appears to be the order of the symptoms ; for an explanation of them we must revert to moral as well as physical causes.

In infancy, when we have no language to express our meaning, instinct leads us, in common with other animals, to exert the organs of voice in the best manner we can ; and experience soon teaches us, that wailings and lamentations procure us commiseration and often relief. These habits once formed are retained in after life, (as Darwin has shewn,) and exerted by association, when relief can no longer be expected from them. This may

be regarded as a moral cause for exertion of voice, and the participation of the respiratory organs in a paroxysm of grief. But another reason may be assigned for the disturbance of this function, besides the struggle arising from a propensity to give utterance to our feelings, and our inability to find language adequate to express them, which presents itself in the influence of abstraction on the mind, upon which the exertion of the muscles of respiration immediately depends.—*Darwin, vol. ii. p.* 158.

The attention being strongly engaged about the cause of grief, the sense of congestion in the lungs is disregarded until it becomes excessive and painful, exciting a convulsive effort to obtain relief, which constitutes a sigh; and the irritability of the diaphragm increasing by the repetition of inordinate action, this at length changes into a sob, or a sudden and more painful contraction.

The flow of tears once excited and associated with certain feelings, may also be much influenced by habit, experience proving, that the irritability of the lachrymal organs may be increased by voluntary indulgence; hence children can sometimes shed tears at pleasure, whereas adults who hold it unbe-

coming, and therefore resist the propensity, soon lose the habit altogether.

But there must be a physical as well as a moral cause for the sudden increase of this secretion; and by a careful analysis of the symptoms, we may perhaps find a clue to its explanation.

Flushing of the face, redness of the eyes, and sense of weight or fulness in the forehead, indicate determination of blood to this part of the brain: and contiguity of the lachrymal glands may produce their participation, as determination to a secreting organ, according to the view already given, must augment secretion, unless the distension of the vessels be sufficient to cause the constriction of their mouths, which suspends secretion; hence moderate grief causes tears, but the most violent is unattended with them, and often productive of more serious consequences.

In infancy, when the natural growth and evolution of the organs require, as Cullen beautifully explains, a greater degree of plethora in the head, the irritability of these parts is consequently greater, and tears are more readily called forth; acting as a local evacuation, which affords a degree of relief, proverbial for its efficacy. This evacuation, it may be observed, is not confined to the

lachrymal glands, but extends to the conjunctiva of the eye, and to the membrane of the nose, irritated by the tears passing into the nasal duct, or perhaps participating in the effect of general determination to the head. That determination of blood is what ultimately produces this effect, and that it does not depend alone upon the moral nature of the passion, appears from its attending others of a very different moral nature, which agree also in causing determination, as joy when excessive, laughter and anger; and from the increased secretion of tears attending simple catarrh, measles, and some other diseases.

The irregularity of the pulse naturally follows from interrupted respiration, alternately retarding and accelerating the passage of the blood through the lungs.

The most important symptom of all yet remains to be accounted for, which is the cause of determination to the vessels of the brain, producing congestion in that organ, with all the fatal consequences that occasionally arise from an excessive paroxysm of grief, such as convulsions, apoplexy, mania, and sudden death.

I shall offer what appears to me the most probable solution of this problem; but whatever may be thought of the explanation, the

fact of increased determination is unquestionable, and the inferences drawn from it rest upon the fact itself, and not upon the explanation proposed as its probable cause.

The blood-vessels, in common with other organs, derive their power of feeling and moving from their nerves, and the vascular system, as well as other parts, is in some instances supplied with cerebral, and in others with gangliac nerves, as the vessels derive them from the branches ramified on the contiguous organs; and consequently we should expect them to participate in the nature and affections of these organs. This we accordingly find to be the case. The vessels of the surface are more subject to mental influence than those of the centre, and those of the face shew more sympathy with sensorial impressions than other parts of the surface; but the vessels of the brain itself, which is the peculiar organ of moral feelings, are of all others most subject to mental sympathy. The influence of attention in increasing, and that of abstraction in diminishing the perception of internal irritation, and consequently the action of vessels dependent upon that perception, have already been shewn, and to this cause I conceive may be referred the suspended contractions and consequent congestion

of blood in the vessels of the brain. As the stronger effaces the weaker impression in the same organ, violent efforts of thinking, or other powerful causes of abstraction, as grief, impair the perception of internal distension in these vessels, suspend their efforts of contraction, and produce determination to the organ. Fear, it may be said, also strongly engages the attention, and should also cause primary congestion; but its reference to bodily feelings already suggested, constitutes an important distinction; while grief has an opposite tendency, rendering the mind regardless of bodily feelings.

The disturbed function of the viscera in less violent and more protracted grief, may be sufficiently accounted for by the general participation which the vessels experience from considerable local changes, impairing the irritability of the whole circulating system; the effects of which will be most considerable where previous debility pre-disposes to organic derangement: if it be the brain, mania; if the stomach, dyspepsia; if the liver, jaundice; if the lungs, asthma; or any other disturbance of function may arise, according to the peculiarities of different constitutions.

Bichât's notion, that the passions are not

animal but organic feelings, and that each has its seat in a particular organ, as love in the heart, affection in the bowels, grief in the liver, envy in the spleen, is too obviously erroneous to require studied refutation.

## JOY.

This passion in a moderate degree produces effects so nearly the same as those of hope and pleasure, to which it also bears a close resemblance in its moral nature, that any further illustration would be superfluous. When excessive, the relaxation of vessels and determination to the brain may become immoderate, and dangerous consequences follow: hence apoplexy, mania, &c. are found sometimes to result from it.

## ANGER.

As we find a striking resemblance between grief and anger in some of their physical effects, we are naturally led to inquire whether any analogy can be traced in their moral nature. The causes inducing them are widely different; the only affinity they seem to

bear to each other relates to the following points :—Both are in some measure of a retrospective nature as to their cause ; both excite the same propensity to give utterance to our feelings, relief being in some degree obtained by our being able to accomplish this, and a still more painful struggle arising when we are not so ; and lastly, both have the same power of abstracting the mind from corporeal feelings. Neither of these emotions arises from, or appears to have any relation to bodily pain.

Anger may be excited against a person who causes pain, but the person and not the sensation, is the object of anger ; the moral feeling diverts the attention from the corporeal feeling for a time, and fixes it upon the voluntary agent. Hence persons fighting are often inconscious of the wounds they receive.

These appear to be the only points of analogy between the two passions ; but they are the most important, as already shewn, in a physiological point of view, as they account for two emotions, in many respects so opposite in their moral nature, producing effects so similar on the bodily economy.

A short exposition of their symptoms will shew the extent of this resemblance.

In anger the face is flushed, the eyes red

and fiery; the temporal arteries beat forcibly; the chest heaves, and respiration becomes hurried and laborious. In infants, tears flow abundantly, and the organs of voice are loudly exerted in expressing the feelings of the mind. The pulse becomes full and strong, and the heart beats with unusual force and frequency. In advanced life, serious consequences often result from a violent paroxysm of rage, similar to those produced by excessive grief, such as effusion into the brain, the bursting of a blood-vessel, an attack of mania, or a fit of apoplexy.

These symptoms afford indications of strong determination to the head, as well as those produced by grief, and like them may be referred to the influence of strong mental abstraction on the vessels of the brain. Participation of the organs of respiration may also arise from the strong propensity to exert the organs of voice; and at the same time these are accompanied with increased action of the heart and arteries in a much more eminent degree than in grief; for which the following reason may be offered. Grief induces a kind of abandonment from despondency, causing every muscle to relax, and every function to languish. Anger excites to strong muscular exertion, from the desire to resent

an injury: thus we often see every muscle called into action, the hand clenched, the teeth firmly closed, the chest raised, and the breath for a moment suspended, while every limb is thrown into an attitude of menace or assault. This sudden contraction augments the force of the blood, increases the action of the heart and congestion in the head; but continued muscular exertion, whether employed in assault or self-defence, may subsequently diminish the danger of organic injury by equalizing the flow of blood; while change of object eventually brings other passions into play, and anger becomes modified by fear or desire of revenge.

As increased circulation within certain limits contributes to increased power of exertion, we may see a final cause for the connexion between the moral and physical effects of anger; all the energies of mind and body being called into action by this emotion. The effects of an immoderate paroxysm of rage have indeed an opposite tendency, like every action and impression that is inordinate, destroying the power of exertion. The following narrative related by Dr. Gregory, of Edinburgh, in his lectures on the practice of physic, may serve to illustrate the fatal

consequences resulting from the excess of grief and anger.

The story resembles in some respects that of Isabella, or the fatal marriage; the subject of it being a woman of low station, shews the same feelings to belong to every class.

A woman, whose husband had been some years absent at sea, had married another, in the persuasion that the former was dead; but the first husband returned, and claimed his wife, who went back to him, and after some time every thing was forgotten; they lived happily together, and she had a child by him. Having quarreled one day with a female neighbour, (when her child was only a few weeks old, and before her strength was perfectly restored after confinement) a scolding match ensued, and her antagonist insinuated that she had married a second husband, knowing the first to be still alive. The indignation excited by this unjust charge brought on an attack of mania, and several weeks elapsed before she was restored to her mind. Her child had in the meantime been given in charge to another woman, and shamefully neglected. When it was brought back to the mother, the shock of finding it half-starved produced an almost instantaneous attack of

catalepsy. She became perfectly insensible of every thing around her, with her eyes fixed, her body motionless, and her breathing scarcely perceptible. If a limb were raised or extended, the muscles becoming rigid, retained it so for a short time, until it gradually sunk into its former position. Various means were employed to restore her, but without success; till it was deemed expedient to try what the sight of her child would do. It was brought to her; but she disregarded it. It was placed directly before her, and she now seemed to become sensible of it, followed it with her eyes, and smiled; and at length stretched out her arms to receive it. When it was given to her, she pressed it to her bosom with a convulsive force, so great as to endanger its life; and its removal became necessary. The consequence was fatal; mania immediately returned, and alternated with catalepsy during the space of three days, when she expired.

These circumstances, relative to the effect produced by the sight of the child, were obtained from the nurse; the Professor, with a delicacy highly honorable to his feelings, having withdrawn from the room, and advised his pupils to do the same.

## PITY.

This passion is so nearly allied to grief, both in its moral nature and its physical influence, that it requires no separate illustration. It may be regarded as sympathetic grief.

## HATRED.

Hatred bears a close relation to anger, and its symptoms will be easily understood from what has been said under that head. In fact, it may be regarded as rooted and permanent anger.

## LOVE.

The effects of this passion are not unfrequently confounded with those of others, which it serves to call forth and bring into action, as hope, fear, joy, grief, anxiety, jealousy, and disappointment, none of which are essential to love, though all occasionally combined with it. In order to place its nature in the clearest point of view, we should select an instance which is least likely to involve any subsidiary feelings.

If the passion be not declared, doubt and apprehension must necessarily accompany it ; if not reciprocated, hope may attend and modify its symptoms, or fears may arise and alter its influence ; if there be no room for hope, grief or jealousy will probably interfere ; and it will be impossible from such an example to form a just estimate of its real nature and effects.

Love being a noble and generous passion, is most likely to rouse those feelings that accord with its character ; but under particular circumstances, the bad as well as the good passions may be called into action, and the real influence of this emotion be obscured or disguised. In selecting the following instance as most illustrative of its nature, it is not meant to imply that this passion can only be truly felt when reciprocal, but that it can then only be divested of correlative emotions. The emotion of which I propose to investigate the nature and effects on the animal economy may be defined,—that attachment between the sexes which springs from a mutual congeniality of mind, occasionally awakening every inherent sensibility.

Without searching minutely into the origin of those propensities which naturally endear the sexes to each other, and form ties

more strong than friendship or kindred ; and without pretending to offer any thing new, or to exhaust a subject so extensive and fertile, I propose simply to state a few of those motives which appear to me most strikingly to illustrate its moral nature and origin.

The love of pleasure and the love of power are alike common to both sexes, but the means of commanding them have been differently apportioned to each ; both being made in some measure dependent upon the other ; and this circumstance seems to form the first natural tie between male and female.

Bodily strength, and the corresponding attributes of mind, have been allotted to man. Delicacy of form and gentleness of nature are more peculiarly the portion of woman. Conscious strength and love of power in the former, weakness and sense of dependence in the latter, make the one as ready to receive as the other to afford protection, while mutual pleasure and reciprocal advantage spring from this union.

Pride, which is a principle closely interwoven in our nature, and too often proves the bane of friendship betwixt man and man, is here prevented from intruding by the diversity of attribute between the sexes, leaving to both a conscious excellence without excit-

ing rivalship or jealousy; each commanding the admiration of the other, but neither experiencing a sense of inferiority or degradation.

Regarding the passion of love as the immediate result of mutual sympathy, its perfection must correspond to the extent and variety of this reciprocity of feeling; to which congeniality of sentiment, similarity of taste, and unison of temper, cannot fail to contribute; and the more closely they are found to accord, the more firmly will the attachment be cemented, and the more certain the prospect of its duration.

It cannot be denied, that attachments between minds that have little delicacy or refinement are often formed without any regard to moral perfections; beauty and loveliness, as an ingenious philosopher has lately illustrated with considerable success, being no self-existent or abstract qualities, but wholly dependent upon and relative to the feelings of the beholder, what is capable of exciting the most lively emotions in the breast of one person awakening no pleasing association in that of another, who is endowed with less warmth of feeling and less delicacy of sentiment. The degree and perfection of the passion must therefore depend as much on the

mind of the individual who experiences it, as upon the object for whom it is entertained; and from diversity of character every variety of taste may be accounted for, and every gradation of love be produced, from more sensual desire to that feeling which ennobles and exalts human nature.

The physical influence of this passion, exclusively considered, cannot be otherwise than productive of beneficial effects on the animal economy, from its analogy to joy and pleasure; but having the peculiar faculty of awakening all the sensibilities of our nature, its indirect influence comprises that of every other emotion of which the human mind is susceptible. Fear, hope, grief, joy, pity, anger, may be roused by turns into action, and produce effects on the bodily economy often confounded with, though widely different from those of love. To enumerate these would be recapitulating what has been already stated in separately treating of each of these passions, and any one may be able with a little reflection to analyze the particular emotions by considering the concomitant circumstances, and thus alloting to each its due portion of influence in the effects produced on the animal economy.

This concludes my observations on the

economy of the sensations and passions, or the connexion between sensation and motion, which I regard as the more simple phenomena of life. We shall hereafter treat of others of a more complicated nature; but we have previously to inquire into the natural means of restoring the capability of sensation and the faculty of motion. After which we shall be better prepared to explain the derangement of function incidental to the bodily organs, and the influence of medicine in restoring their healthy performance.

# CHAP. IV.

# NATURAL MEANS

OF MAINTAINING

# Sensation & Motion.

## SECT. I.

# NUTRITION.

CHANGES attendant upon the Performance of the Functions. The Means of Reparation.——How we are led to seek them.—Causes of the Degree of Sensibility possessed by internal Organs.——Physical Cause of Hunger inquired into.——Not owing to Attrition of the Fibres, Irritation from the Gastric Juice, or Collapse of the Organ.——Its apparent Cause deduced from the Symptoms.——Explanation of the Phenomena attending it.——The Sense of Nausea; its Nature and Cause.——Its Affinity to Hunger.——The Sense of Thirst; its Nature and Cause.——Different Modifications of it in Health and Disease.——Assimilation, how effected.——Cause of Shivering and Hectic Flush after Eating.——Absorption, how accomplished. Deposition, probable Means by which it is effected.——Separation of Parts previous to Excretion.——Means by which Solution is effected.——Excretions derived immediately from the Blood.——Solid Nature of the Feces accounted for.

HAVING been led to the conclusion, that every sensation excited is the effect of a transient change produced on the nerves, and that every motion is the consequence of a change of state in the moving fibre, effected by the nervous influence, we are naturally induced to inquire by what means the animal

body is enabled to restore these incessant changes, so as to render the organs fit for supporting the continued performance of their different functions.

This renovation, as experience testifies, is produced by food and rest, nature's grand restoratives: the former affords fresh materials for replacing those which are no longer fit for the performance of these functions; and the latter suspends, in a great measure, these functions themselves, and allows time for a more perfect assimilation and deposition. Instinct alone impels us to seek these means of restoration; prompting us by the uneasy sensations in voluntary organs, attendant upon the excessive changes which over-action produces; and by the impeded functions, which result from the same changes in organs of involuntary motion.

The faculty which different organs possess of exciting mental perception of the impressions they receive, or the changes they undergo, seems, as before stated, to bear a relation to the proportion of their nerves, which proceed directly to the brain, without the interruption of those knots or enlargements termed ganglia. As internal organs are chiefly supplied with gangliac, and external with cerebral nerves, the latter possess this faculty

in a much more eminent degree than the former, which from ordinary impressions experience no sense of feeling sufficient to excite consciousness in the mind. The tongue, which is amply provided with cerebral nerves, is highly sensible of every impression it receives; but the same substances cease to produce a sensible impression as they descend into the stomach; a degree of heat or cold that could be scarcely borne in the mouth being hardly perceived in the stomach. The final cause or design of this peculiarity sufficiently appears in the necessity of our being made acquainted with the nature of our food, while we have yet the power of rejecting it; whereas the continued mental perception of the changes it induces could answer no useful purpose in the animal economy. The stomach is not, however, wholly destitute of the faculty of exciting mental perception, being supplied from the eighth pair of cerebral nerves, to which it probably owes the capability of exciting the sensations of hunger, nausea, and the perception of any strong and unusual impression. The exciting causes of those sensations which are habitual to this organ, as hunger and thirst, are points about which physiologists have long been at variance, and still continue to be so. Instead

of engaging in an elaborate refutation of the many opinions that have been offered on these subjects, I shall briefly state some of them, and then offer what I conceive to be their most probable cause, leaving my opinions to stand or fall by their own merit or demerit.

## HUNGER.

Some have ascribed hunger to the attrition of the fibres of the stomach against each other; but this opinion requires that it should be previously ascertained, whether this organ is ever so much emptied as to bring its sides into actual contact. Others ascribe it to irritation from the gastric juice corroding the stomach; but I can see no reason for supposing any fluid painful to an organ that is in perpetual contact with it; and I think it contrary to reason and analogy, that any organ should secrete a fluid to irritate itself. Others ascribe the sense of hunger to collapse of the stomach; but why should collapse be painful? The bladder, when collapsed or emptied, is not painful; and no reason is offered why the stomach should be so.

But none of these opinions, if admitted, are at all adequate to the explanation of the phenomena.

Thus why does hunger cease spontaneously, then recur again? If it arise from attrition or the irritation of the gastric fluid, what suspends for a time the operation of these causes and then induces its recommencement? If from collapse, why does it cease occasionally without food being taken, or why does a dose of laudanum remove it? Why does fasting beyond the accustomed hour cause indigestion? The reverse should arise from accumulation of the gastric juice.

These and many other phenomena remain unaccounted for upon any of these suppositions; let us then re-consider the symptoms, and inquire what they lead to.

After taking food, the chyme, as it is stated, does not begin to pass the pylorus for a considerable time, whence we may conclude that the action of the muscular fibres is not very powerful at this time, or the contents of the organ would be thrown up into the cardia or forced through the pylorus.

The closing of the pylorus after repletion of the organ may be referred to increased distension of the stomach, mouths contracting, according to a general law, as their organs relax and become over-distended. The subsequent relaxation of the pylorus may be refer-

red to diminished bulk of the organ from the absorption that has taken place.

When the food passes the pylorus, the muscular fibres begin to act with more vigour, excited by the natural stimulus of distension; not however the uniform distension of the food contained, but the pressure alternately applied and removed at every descent and ascent of the diaphragm.

From whence we may conceive why moderate exercise, which accelerates respiration, contributes to promote digestion if not taken till after the pylorus relaxes, but before that period increases the constriction of that sphincter and retards digestion.

As a depletion of the organ advances, the extent of contraction exerted by the muscular fibres must keep pace with the decreasing bulk of the organ; and this indicates an increasing mobility from continued action, which well accords with the principles formerly deduced,—mobility at first increasing with exertion.

As the organ becomes nearly empty, the extent of contraction increasing in proportion, painful or uneasy sensation arises. Does not this indicate the next stage of action or painful sensation attending excessive contraction? But let us proceed.

If food be not taken soon, the painful sensation increases for a time, and then often subsides spontaneously. Does not this indicate the last stage or suspension of action from want of power to act?

But if food be taken, the organ soon exhausts its remaining portion of mobility whilst we are eating, and then remains in a state of quiescence, and hunger ceases, as a state of relaxation follows one of over-action. The pleasing impression of the food may also contribute to promote this relaxation, as well as the exhausted state of the fibre.

The sensation of hunger I conceive, then, to be the perception of painful exertion or inordinate contractions in the muscular fibres of the stomach; being analogous, as Bichât had conjectured, to the sense of fatigue produced by over-action in other organs of motion. We may now proceed to shew how far this explanation accords with other phenomena.

After the sense of hunger is removed by repletion of the organ, depletion does not commence for a considerable period;—a state of previous over-action requiring one of subsequent rest.

The final cause of this suspension is pro-

bably intended to allow a proper period for the more perfect maceration and absorption before the chyme is transmitted to the intestines. It might perhaps be expected, if hunger be a sense of over-action in the fibres of the stomach, that these efforts of contraction should cease the moment they become painful. But it is to be observed, that the stomach is not an organ of voluntary motion; and even in voluntary organs we do not find this to be always the case. Reasoning, therefore, a fortiori, it is less likely to be so in involuntary organs: thus cramps or spasms are often kept up in the limbs for a considerable period, though productive of much more pain than the cause exciting them.

A dose of laudanum removes the sensation of hunger. I think John Hunter somewhere offers a conjecture, that the pain of an inflamed part does not arise from over-distension of the inflamed vessels; but from their inordinate and ineffectual efforts to resist distension: an opinion highly probable, as emollients, which increase the over-distension, by inducing relaxation, relieve the pain by allaying the efforts of resistance: in like manner, a dose of laudanum, by allaying the action of the stomach, removes the sensation of hunger.

When hunger ceases spontaneously, it recurs again after a certain time, which likewise admits of easy explanation. If the natural customary support of food be too long withheld, a state of relaxation and debility succeeds to over-action, and the efforts of contraction cease spontaneously; but after action has been suspended long enough to produce a renewal of power, any exciting cause gives rise to a recommencement of action; and thus hunger ceases and returns. The exciting cause to this renewal of action may be fresh distension, suddenly induced by the generation of air, supposed to arise from incipient fermentation; and it appears that the mind has also some influence, as thinking of hunger increases it. The distension produced by air is very different from that of food; the latter from its specific gravity pressing chiefly on the lower, the former from its levity ascending to the upper surface of the stomach, hence producing nausea and eructations.

Liquids allay the sense of hunger; but their effect is transient, as they soon pass off.

As the regular returns of motion and rest, at stated periods, improve the tone of every organ; whereas over-action, and long inaction alike, impair their energy; we may easily

conceive why eating too much, and too long fasting, are both liable to cause indigestion.

As hunger depends not merely upon the alternate distension and collapse of the stomach, but upon the different stages of action, and fatigue in the moving fibre; persons of weak digestion are more subject to the quick return of hunger, because the weakest fibre soonest experiences fatigue, which may, in some cases, recur before the stomach be half empty. Accordingly we find, that the weakest constitutions are least able to bear fasting, and causes impeding digestion sometimes induce voracious appetite. In short, all the phenomena appear to admit of solution on these principles, which derive additional support from their conformity to the general laws of the animal economy.

## NAUSEA.

The sense of nausea bears some affinity to that of hunger, and is with apparent reason referred to the inverted, or altered action of the stomach; as eructations, which often attend it if the stomach be empty, seem to prove. That nausea is the per-

ception arising from a change in the action of the organ, and not the direct impression of the substances producing that change, is manifest from the fact, that this sensation remains nearly the same, varying in degree rather than in kind, although induced by fifty different substances, bearing no affinity, or resemblance to each other, in sensible qualities. It is probable, however, that nausea is not only an unnatural, but also an excessive action of the organ, and hence the affinity it bears to hunger.

## THIRST.

The sensation of thirst is also connected with the state of the stomach, but has its immediate seat in the fauces. The cause of this sensation is with apparent reason referred to suppressed secretion in the glands and membrane which serve to lubricate the mouth and throat: but the remote causes, or the reasons for this secretion being suppressed, are very far from having been satisfactorily accounted for; though every thing that tends to elucidate the nature of a symptom that forms so prominent a feature in many intricate diseases, cannot fail to enlarge our views of the animal economy.

It is surely needless to notice the fallacy of the opinion, that this symptom arises from a general expenditure of the fluids leaving the secreting vessels empty. This is sufficiently answered by the fact, that thirst is as effectually, and in disease more frequently removed by the abstraction, than by the addition of fluids; and drinking to excess is at all times more apt to excite than allay thirst; add to this, that cool air and mental emotions will often remove it. The cause of this suppressed secretion must then be sought for elsewhere, and on reverting to the nature and attributes of the secreting vessels, we shall find a clue to its explanation. These vessels contract from the feeling of internal irritation, and like all other moving organs are liable from unusual irritation to exert that effort to excess, their mobility increasing with exertion until a degree of exhaustion and spontaneous relaxation supervene; their sphincters obey the same law, but as the contraction of the vessels in part takes off the impression of the blood from the sphincters, and their relaxation tends to increase it, the action of the latter diminishes as that of the former increases, and on the contrary increases as it diminishes, so that they in some measure alternate with each other; the sphincters relaxing when the

vessels contract ; and contracting as the vessels become relaxed and over-charged.

Now either of these causes may produce suppressed secretion ; namely, excessive constriction of the vessels preventing the transmission of fluids to their mouths, or excessive relaxation of the vessels causing constriction of their sphincters ; and it is probable that either of these causes may occasionally operate. It is next to be inquired, then, when the effect originates in the constriction of the mouths from over-distension of the vessels, and when it arises from constriction of the vessels themselves ?

Experience shews us, that shrinking and constriction of the capillaries are usually attended with a sense of cold in the part, and their increased fulness or distension with an augmented sense of heat ; and this may assist us in ascertaining when the effect is connected with the one, and when with the other of these causes. In the cold fit of fever, in which thirst prevails as much as in the hot fit, hot liquids, as Dr. Currie remarks, are more grateful than cold, and the reverse of this is observable in the hot fit. Now the opposite condition of the vessels in the two stages would lead us to infer, that the thirst

arose from their excessive constriction in the cold, and their over-distension in the hot fit; the reason of which states will be sufficiently accounted for when we come to investigate the doctrines of fever.

When thirst arises from excessive fatigue, immediately succeeding to copious perspiration, there is sufficient reason to conclude that the small vessels, being unusually pressed upon by increased circulation, have been gradually yielding to the augmented impulse of the blood, thus producing perspiration; until the relaxation arriving at that point which occasions constriction of the sphincters, gives rise to suppressed secretion, causing thirst.

Thirst sometimes attends perspiration, which also admits of explanation:—Immoderate constriction, and relaxation of secreting vessels are alike productive of suppressed secretion; but these changes, within certain limits, only alter the quantity and quality of the secreted fluid; increased tone or diminished area of the vessels rendering the secretion thinner, relaxation or increased area of the vessels rendering it thicker; but thickened secretion alone may produce thirst, and the clamminess of the mouth in some cases distinctly felt, indicates this altered

state of the fluids secreted; while its immediately preceding a total suppression confirms the probability of their both originating in the same cause, namely, relaxation in the vessels, which gradually yield to the increasing impulse of the blood, till they become overdistended, and their mouths constricted.

The means by which thirst is removed are easily explained on this view of its nature and cause. Perspiration, by evacuating the vessels, relieves their distension, and takes away the constriction of their sphincters. Cold air or cold water externally applied to the surface of the body, by physically constricting the vessels, has the same effect. Warm liquids may act as emollients do to an inflamed part; the relaxing influence of warmth and moisture takes off the constriction of the mouths of vessels to which it is directly applied, and thus restores the secretion. Taking a pebble into the mouth will sometimes allay thirst by its impression on the mouths of the ducts, producing their relaxation according to the general law of external impressions. A glass of wine or spirits may also, in some cases, by its external impression, take off the constriction of the mouths of the vessels, and relieve thirst; and mental emotions,

by their influence both over the sphincters and over the vessels themselves, may produce a similar effect.

It may, with some reason, be objected that morbid and natural thirst are different. The fact appears to be, that the species of thirst which is allayed by copious draughts alone, has besides the causes above stated, a near affinity to hunger, arising partly from the want of repletion in the stomach to relieve inordinate contraction in the muscular fibres.

Prompted by these different sensations, we are induced to seek those means which instinct or experience points out as affording relief, and the food being once received into the system undergoes a succession of changes until it is assimilated to the body; while those particles which are no longer fit for the purposes of life are detached, dissolved, and carried back into the common mass of circulating fluids, until they are finally excreted from the mouths of vessels terminating on the external or internal surface.

## ASSIMILATION.

THE function of assimilation depends chiefly upon mixture and dilution, which is performed

by the flow of the different secreted fluids caused by the relaxation of the ducts, from the external impression made by the food coming in contact with them, in its passage through different organs. Thus the saliva assimilates it to the organ of taste, the gastric fluid to the stomach, the bile and pancreatic juice to the intestines; the glands of the absorbents probably perform some additional process of assimilation, so that the food is deprived of all irritating qualities before it is transmitted to the blood. A slight degree of irritation is, however, still perceptible after eating in persons of irritable habit, about the period when the chyle is supposed to enter the blood; indicated by a tendency to rigor, followed by a hectic flush; effects probably dependent upon the altered state of the fluids exciting new and unusual impression, different from the natural stimulus of distension, repeated at regular intervals.

## ABSORPTION.

The function of absorption consists in the reception of the newly assimilated food into the vessels opening into the stomach and intestines, and its transmission through

them, until it arrive at the thoracic duct, and unite with the common mass of the blood.—The admission of fluid into these vessels may be promoted by the contractions of the stomach and intestines, which must necessarily force a portion of their contents into these open mouths; and this once admitted is prevented from returning, by the valves with which the absorbents are amply provided; and consequently every subsequent contraction forcing in fresh fluid must contribute to propel onward the preceding portion.—The same effect will result from the contractility of the vessels themselves; distension being probably the stimulus that excites them to action; which may take place between one valve and another, different portions contracting in succession; and their structure being somewhat analogous to that of veins, they probably accord with them in point of mobility and permanency of action.

The function of deposition, by which the nutriment ultimately combines with and becomes part of the body, may be conceived to depend upon a species of elective attraction, by which each part, as bone, muscle, tendon, nerve, or membrane appropriates to itself such particles from the blood as are suitable for its accretion; and it is not improbable that the nervous influence conduces to this effect.

It cannot be imagined that mere mechanical deposition from the mouths of vessels is adequate to this purpose, as the vessels would be continually filling up; and there appears no physical impossibility to prevent its taking place through the coats of the vessels themselves, aided by the nervous influence, perhaps in some manner analogous to the agency of galvanism in decomposing a solution, and transporting some of the ingredients from one vessel to another along the galvanic conductor.

The separation and solution of such particles as are become unfit for the purposes of life, or for performing the functions of sensation and motion, may arise from the changes they have undergone in the performance of these functions having impaired their vitality, and rendered them subject to the laws of physical action. Now the body is at all times under circumstances most favourable to solution, both with respect to the nature and to the temperature of the fluids, and it is less difficult to account for solution taking place, which must happen previously to absorption, than to conceive how the body, under such circumstances, is ever enabled to resist it. Accordingly we find all causes, that tend to impair the vitality of a part, promote this process;

and solution having once taken place, the fluids are probably propelled into the mouths of vessels as already suggested ; muscular motion, friction, or any cause inducing external pressure concurring to promote absorption; and in some cases perhaps simple capillary attraction may contribute to its commencement, as in absorption from open cavities.

As the demand for absorption appears to bear a relation to the degree of muscular exertion, we may partly perceive the final cause or expediency of this function being made to contribute to its performance, as the means will consequently bear always a due proportion to the end, or the degree of absorption will be equal to the demand for it.

## EXCRETION.

The function of excretion consists in the ejection of the particles separated and absorped, and likewise in the transmission of such parts of our food through the intestines as are too gross to be admitted into the mouths of the absorbents opening into that canal. It seems probable, as Dr. Hamilton, of Edinburgh, in his valuable work on purgatives has suggested, that the greater portion of excrementitious

matter voided from the intestines is derived from the mouths of vessels terminating in them.

The solid nature of the feces is no objection to this opinion, since it is quite as easy to conceive that matters deposited in a cavity in a state of solution may become comparatively solid from the re-absorption of the more fluid parts continually going on there; as it is to conceive how matters received into the minute vessels in the state of solution should be subsequently converted into the living solid. This opinion is farther confirmed by the want of any other visible emunctory for the solids perpetually rejected; and by the continual accumulation of feces under the use of purgatives in some acute diseases, when no food has been taken, perhaps, for some weeks.

By these means then are the changes attendant upon sensation and motion naturally restored; but as the effects of over-action are best removed during sleep, we proceed next to inquire into the nature of this condition of the body, and the organs to which its influence appears to extend.

## SECT. II.

# SLEEP.

ONLY a partial Suspension of the Functions.——In what Degree each Organ participates.——The Organs of Mind, of Voluntary Motion, of Circulation, of Respiration, of Secretion, of Digestion.——Cause of Sleep inquired into.——Relation between the Sense of Heaviness from continued Efforts of Attention, and Weariness from Exertion of the Limbs.—The immediate Seat of these Sensations.——Physical State of the Brain during Sleep, deduced from the Symptoms attending, the Causes inducing, and those preventing Sleep.——Dreaming; its Physical Cause.——Why Dreams are more connected at one Time than at another.——Volition not always suspended in Dreams. Night-mare; its Phenomena and Physical Cause; its Relation to Epilepsy.——Somnambulism; Phenomena and Physical Cause; why occasioned by mental Uneasiness.

AS every organ susceptible of contraction experiences some change from continued exertion, so every one requires in some degree that renovation which is derived from rest and sleep.

Every extraordinary effort of attention or thought is also productive of a sense of pain or uneasiness, which indicates changes

attendant upon over-action in the brain, as distinctly as fatigue in other voluntary organs, and the brain accordingly experiences a suspension of function, and derives a renewal of power from rest and sleep as conspicuously as any other.

Whether the brain enjoy during sleep a perfect suspension of its function, or whether association be still carried on, is by some considered doubtful: if dreaming occur during sound sleep, of which, however, we have no proof, this suspension cannot be perfect. The question is purely metaphysical, and its decision of no importance in a physiological point of view, as comparative rest answers the purposes of renovation nearly as well as complete inaction.

The total relaxation of the voluntary muscles perhaps results, without being actually requisite, from the position in which we sleep, the horizontal posture obviating the necessity for their exertion; but habit teaches many to sleep in the erect posture, and some are able to sleep on horseback; and it is by no means uncommon for people to walk in their sleep, and to exert other voluntary muscles, as those of speech. The organs of respiration and circulation are never wholly suspended from action; and perhaps some

voluntary muscles, as those supporting the lower jaw, may be also regarded as enjoying only a partial rest.

But as every organ endowed with sensation and motion requires some renovation, it is requisite to shew that all in some degree partake of it.

If augmentation of function were a proof of increased action in every organ, this would be very difficult to establish; but we have already seen that some functions are increased by relaxation of the organs, as secretion is augmented though changed by increased area of vessels; and the functions which are performed by chemical agency, such as assimilation of food in the stomach, the changes of the blood in the lungs, and the deposition of nutritive matter from the blood, are better performed during rest than action, not being directly dependent upon sensation and motion. The participation of the brain and voluntary organs in this state has been just stated; the following considerations will shew that of involuntary organs:

The organs of circulation enjoy a very conspicuous diminution of action during sleep, as will appear from the following circumstance:—The heart, which in the erect posture is pressed upon, and distended by the

blood descending from the head with a force equal perhaps to four or five pounds, and the vessels with the whole weight of the incumbent column, are both relieved from this distending force in the recumbent posture; the blood now flowing on a dead level, and requiring little effort to keep it in motion, or prevent over-distension of the vessels; and the stimulus which excites these organs to action, namely, the feeling of internal distension being diminished by the removal of the incumbent column, a state of comparative rest is allowed to them.

The organs of respiration equally participate in a state of partial rest, from the slow return of blood to the lungs; and as more or less general relaxation of the vessels takes place, the quantity sent to the lungs in a given time is lessened by that detained in other parts; and, in addition to this, the changes produced by transpiration, which are augmented by relaxation of the superficial vessels, further tend to supersede in part the necessity for respiration by producing analogous changes in the blood, as rendered probable by Ellis in his valuable Treatise on Respiration.

The organs of secretion are relaxed, as

appears from secretion being more copious, though somewhat altered in quality; thus we find increased secretion of bile and urine, whence diabetic persons are most troubled during the night, and those who are subject to bilious head-aches are usually afflicted with them early in the morning. The altered secretion of other organs is still more obvious; the tongue is more or less furred in the morning; the nose and fauces are generally a little stuffed; and the eye-lids are not unfrequently glued together by the thickened secretion from their edges; and the whole surface of the body is rendered moist and clammy; all shewing relaxation in the secreting and excreting vessels.

Digestion being a compound function, dependent partly on mixture with the secreted fluids, and partly on the action of the organs, its changes are less evident; but we have a proof that the active part of this function is more slowly performed, in the protracted return of hunger; as we do not experience this sensation the moment we awake, although breakfast and supper are less hearty meals than dinner, and notwithstanding we fast frequently twelve hours during the night, while seldom more than half that period

elapses during the day when we are engaged in active exertion, without the returning sensation of hunger.

Sleep then appears to be a general, though probably far from a total suspension of the functions of sensation and motion.

We may now proceed to examine more particularly the nature and immediate seat of those changes which give rise to this suspension or diminution of function.

In treating of the power of motion, we traced a succession of stages attending bodily exertion, exhibiting at first symptoms of increasing mobility, then causing a painful sensation to arise, and at last a diminution or loss of the power of action. The same stages are also observable in the phenomena of mental exertion; the powers of voluntary association increasing as we continue to meditate upon, or discuss a difficult subject, the conception becoming clearer, and the judgment more correct; but after a certain period the powers of mind begin to decline, and the effort of voluntary association now becomes difficult and painful; and at length the faculty of attention is either greatly diminished or wholly suspended. Similar consequences also result (as before stated) from forcibly continuing the effort after it has begun to be

painful; inflammation or symptoms approximating to it being alike incidental to all organs.

Fatigue then, mental as well as bodily, seems to result from changes induced in the organ exerted; and from the nature of the changes that result from forcible efforts of attention too long continued, the uneasy sensation they produce appears to proceed from, or to be closely connected with, change of condition in the minute vessels.

That change of circulation in every organ is productive of change of function is unquestionable, and in none is this more conspicuously true than in the brain, which is generally the first to participate in every alteration the circulation undergoes; partly perhaps from its receiving blood more forcibly and abundantly than other organs, and partly from its being confined on every side by bone, which renders it more sensible of increased or diminished pressure. Thus the mental faculties are impeded by a loaded stomach, and confusion of thought attends a hurried circulation from whatever cause it arises.

It appears highly probable then, that an altered state of vessels is the immediate cause of the uneasy sensation that attends exces-

sive efforts of thinking; and the affinity of drowsiness to the sense of heaviness in the forehead felt when attention begins to be irksome, points out the probability that some connexion prevails between the causes inducing them; the nature of which will appear from a careful analysis of the phenomena.

Experiment proves, that pressure alone in the brain is capable of producing sleep, and injuries of the head often confirm the fact; from which Dr. Whytt was led to infer, that congestion of blood giving rise to pressure was the immediate cause of sleep. But congestion alone does not always produce this effect, or it might be brought on at pleasure by hanging down the head; and immoderate congestion, while the vessels retain the power of action, appears in many cases to prevent sleep by the irritation it excites. If congestion contributes to this effect, which it is highly probable that it does, it seems to be only when it is moderate in degree and attended with some particular circumstance, which remains to be inquired into.

The following considerations lead to the conclusion, that this additional circumstance consists in a state of relative exhaustion in the blood-vessels, analogous to the stage succeeding to painful exertion in other moving organs;

inducing a spontaneous relaxation of the vessels, and causing a slow and full circulation in the head.

The inference is founded on the following arguments:

In the first place, we find all the symptoms attending the approach of sleep to indicate retarded circulation with congestion in the minute vessels of the brain.

The phenomena of motion exhibit in every organ distinct successive stages, and the blood-vessels being subject to the same laws, indicate symptoms of similar changes; circulation being somewhat languid in the morning; more active and vigorous towards noon; quick and irritable about evening; but fuller and slower at night as sleep approaches. These changes occur indeed sooner or later in different constitutions, and vary also in degree; a pulse of fifty-six being natural to one person, and one of ninety-six to another, while children often sleep with a pulse above an hundred.

The symptoms of relaxation of vessels first shew themselves about the lower extremities, where the pressure of column is the greatest; hence in persons of weak constitution, and in old people, we find the legs and feet are apt to swell towards evening. Yawn-

ing and stretching are probably spasmodic efforts, analogous to tonic spasms, to remove an uneasy sensation, which may result from relaxation of vessels causing congestion of blood in the lungs, and perhaps in the region of the neck, extending occasionally to the back and shoulders. This affection sometimes occurs in the morning before we rise, a period when congestion is very likely to prevail in the superior parts of the body, from continuance of the horizontal posture, after sleep has restored the powers of circulation: and congestion may at any time be brought on by mental impressions, which are calculated to induce it, as before explained, by increasing the perception of the feelings that give rise to this effect. Flushing of the face, redness of the eyes, which chiefly derive their blood from the central artery of the retina, and sense of fulness in the forehead, still more unequivocally indicate relaxation and congestion in the vessels of the brain; and the impaired energy of the organ, from this state of circulation, becomes the exciting cause that prompts us to seek relief from the suspension of functions now no longer performed without pain or difficulty. The recumbent posture is resorted to as requiring the least bodily exertion,

and the increasing congestion that follows, soon induces a total suspension of the faculties of voluntary association.

In the next place, all the causes of sleep are calculated to produce retarded circulation, with congestion in the brain.

Moderate and continued exertion, keeping up an increased action in the arterial system, naturally predisposes to subsequent relaxation, and is proverbial for inducing sound sleep. A hearty meal, when no moral cause prevents it, as in the lower animals, evidently has the same effect. This cause produces by its grateful impression a general relaxation of vessels, thus promoting full circulation; while the pressure of the distended stomach on the descending aorta, and all the neighbouring vessels, may cause obstruction, and promote congestion. Extreme cold is known to induce sleep. The constriction of the superficial vessels which cold occasions, must impede their action, and retard circulation; at the same time that the increased afflux of blood to the internal parts must excite congestion. This is perhaps further promoted in the head by the fur caps, and other means, generally adopted by travellers under such circumstances, to keep the head warm.

Continued and powerful exertion, which quickens the circulation, is consequently found in extreme cold, to be the sole preventive of sleep. The horizontal posture, as already explained, every way contributes to retard circulation, and from simple gravitation promotes congestion in the head, and consequently favours the accession of sleep. There are, however, exceptions: the corpulent and plethoric often sleep sooner in the erect, or rather reclining posture; which may be thus explained: Circulation in them is at all times slow and languid, the vessels being overcharged and disposed to yield to the pressure of column, which is shewn by the tendency to swelling in the lower extremities towards evening; they require therefore only a slight obstruction to overpower them, and induce their relaxation; which in a sitting posture is promoted by the pressure of the incumbent parts, and the resistance of the clothes, rendered more tight, especially round the neck and waist, by the reclining of the head, and the sinking down of the abdominal viscera, and partly perhaps by the unequal pressure of the body on the seat which supports it. All these causes tend to obstruct the circulation, to induce a relaxation of vessels, and to promote

sleep. In the horizontal posture these causes are removed, and the vessels relieved from oppression; and being partially revived by the rest, surreptitiously as it were, obtained in the erect posture, now resume their office with activity, and thus for a time quicken circulation in the horizontal position, and prevent sleep.

Among the causes that promote sleep, there are many others which are insufficient, when separately present, but under favourable circumstances give rise to it. Thus a warm fire, after previously taking exercise in cold air, or after a full meal, or towards evening, when the vessels are predisposed to relaxation, has the effect: but when the vessels are not predisposed to relax, or when one of the causes only is present, as a warm fire, or a hearty meal, this, instead of retarding, may accelerate circulation.

And thus we find every thing concur to prove, that congestion must be joined with relaxation of vessels, or full and slow circulation is required to produce sleep.

As the drowsiness preceding sleep is not so much an inability to act, as an aversion to action, it may be overcome or encouraged to a certain extent; and habit has considerable

influence in accelerating or retarding the period of its recurrence, attention increasing the effect of this sensation, as it does of every other; whence thinking of sleep, or fancying ourselves sleepy, may help to induce drowsiness; other moral causes may also concur to promote or prevent it. Old people having fewer motives for exertion, are more disposed to sleep; and children may be lulled to rest by the humming of a tune, or the motion of a cradle. Drowsiness may for a time be overcome by exertion; but when the continuance of action has been kept up for an unusual period, further resistance becomes insupportable, and the soldier will sleep in the midst of danger, and the criminal to the very hour of execution. The nearer we approach to this state, the more perfect will be the sleep induced; whence old people who doze much, and use little exertion, seldom sleep soundly.

Lastly, every circumstance that accelerates circulation or removes congestion prevents sleep; such as active exertion of mind or body; strong impressions of joy, grief, fear, or anger; and likewise such causes as tend to produce immoderate congestion, which is equally unfavourable to sleep, from the irritation it excites; thus, according to circum-

stances, evacuations may either impede or promote the approach of this state, which appear, from the foregoing arguments, to require the conjunction of retarded circulation with moderate congestion in the vessels of the head.

When sleep comes on slowly and feebly, the eyes are closed, and volition suspended before association of ideas ceases. In this state the perception of external objects being wanting, we soon forget our situation; and the strange images which imagination presents in this imperfect state of the mental functions, between sleeping and waking, constitute our dreams.

## DREAMING.

Dreaming occurs not only at the accession, but also at the retrocession of sleep.

When the tone of the vessels is so far restored as partially to relieve the congestion, the powers of association recur; but the eyes not being immediately opened, we are not conscious of our situation, and if we reason at all, it is generally from imaginary perceptions.

Thus we sometimes dream we are in a foreign land, and wonder how we came there, and often retrace events to ascertain this point with considerable accuracy; until the surprise excited by the novelty of the internal perceptions becomes an inducement to bodily exertion, and the attempt to move helps to restore the powers of action, and a slight effort, by opening the eyes, corrects the judgment, and dispels the illusion.

During dreams the lips are often observed faintly to move, and not unfrequently words are uttered. When they are, or appear to be so, our dreams (as Dr. Wilson observes, in his Treatise on Febrile Diseases) are generally more connected, from the ideas being longer detained, and time allowed for a more perfect association and comparison. In this case the incidents will appear less confused, and the reasoning more correct. The time occupied in dreaming will also be more accurately measured, as the rapid succession of ideas will be restrained from the time required to give them utterance: for although words be not actually expressed, it is probable the effort is feebly made, and may occupy the same time as if they were. When this is not the case, a whole history of fire, thieves, and

murder, (as Darwin observes,) may be dreamt during the creaking of a hinge or the opening of a door.

The celebrated Dugald Stewart ascribes all the phenomena of dreams to the suspended influence of will leaving association of ideas uncontrolled: but the very perfect train of reasoning, or voluntary association, that often occurs, and the very frequent exertion of the organs of speech, and sometimes of the muscles of voluntary motion, as in somnambulism, rather shew that the exertion of the faculty of volition, like every other depending upon the brain, is only partially impeded by the physical state of the organ; this suspension being the consequence, and not the cause, of the physical changes.

The following dream, an account of which was sent to me by a friend, shews distinctly the exertion of voluntary association in this state of the sensorium. He had recently been on a visit at my father's; and a few days after his return to Ireland, dreamt he was again in Liverpool, which occasioned considerable surprise. He tried to recollect himself, and distinctly traced back all the principal occurrences of his departure, journey home, meeting with his friends, giving orders

for business, &c. and at length convinced himself that unreal images were presented to his mind. But again he looked around, saw, heard, and spoke with the friends he had left; yet still persuaded that these could be no other than imaginary perceptions, came at length to the singular conclusion that he had lost his senses; until the agitation excited by the idea of insanity, called forth a struggle which awoke him, and unravelled the mystery. Now this effort of recollection implies an act of volition; and so connected a train of reasoning proves a state of the mental faculties far removed from fortuitous and incongruous association; or such as might result, according to Mr. Stewart's idea, from the suspended influence of volition leaving this faculty without control.

Experience, as before stated, seems to prove that the mental faculties, as perception, judgment, volition, depend more immediately upon the state of the cerebrum or brain. It likewise appears from similar experiments, and from injuries of the spine, that the function of motion is more immediately dependent upon the state of the cerbellum, or little brain, pressure on this organ being found to induce convulsions, not sleep.

Now we may easily conceive that the unequal removal, or accession of congestion, restoring or impeding the function of one or other of these organs in a greater degree; or excessive congestion in either of them, may induce different phenomena.

## INCUBUS.

If congestion remain in the cerebellum and spine, when removed from the brain, it will produce the partial restoration of the mental functions, while those of the body remain impeded; and much alarm will naturally result from this consciousness of the loss of the power of motion. As some of the involuntary motions may also participate, or those termed mixed motions, as respiration, an uneasy sense of oppression will probably attend this condition, and may serve to account for the nature of the associations that generally arise in the mind; daily experience confirming the fact, that our dreams are much influenced by uneasy sensations.

The following circumstance related to me by the gentleman to whom it happened, serves to illustrate this fact. He dreamt that in car-

rying some large weights, he let one fall and crushed his toe. On awaking he found to his surprise, the toe swollen and really painful. But the pain continuing to increase for some days, he applied to his physician, and was informed that his case afforded a fine specimen of the first attack of gout.

That state of the sensorium induced by unequal congestion, termed incubus, or night-mare, is generally attended by a sense of terror and anxiety, with the desire to move, without the ability. A load is felt on the breast, or some frightful image is presented to the mind, prompting us to flight or resistance, which the limbs are unable to afford; until a sudden effort restores the power of contraction, removes the congestion, and dispels the symptoms of this unpleasant affection.

Some of the older writers, as Cælius Aurelianus, have classed incubus along with epilepsy; and the termination of this affection, when very frequent, in epilepsy; and the fact, that epileptic persons are peculiarly liable to it; while the same causes induce both, are circumstances that shew their affinity, and serve to throw light on the nature of both these affections.

The causes most frequently inducing in-

cubus are, a heavy supper, and the supine posture; two circumstances that strongly confirm the probability of its connexion with undue congestion in the cerebellum and spine. Its occurrence when lying on the side is comparatively rare, but certainly not impossible.

If the faculty of perception and judgment be but imperfectly recovered, after the use of the limbs is restored, this will produce the singular affection termed somnambulism.

## SOMNAMBULISM,

Is a perfect restoration of the faculty of locomotion, with only a partial perception of external objects, and an imperfect use of reason.

The eyelids are generally raised, but the objects painted on the retina convey no impression, or a very imperfect one, to the mind, from the pressure on the brain obstructing perception, or the incapacity of the nerves to excite it. In some cases vision is partially recovered, as persons in this state will unlock doors, having taken a key out of a drawer on purpose; but as they generally awake by striking against something in their way, it is clear that vision is only partially or indis-

tinctly restored. The mind is throughout in a state of dreaming, fixed on some imaginary conception, regardless or imperfectly conscious of surrounding objects. When spoken to, people in this condition, if asked where they are going, will often answer without awaking, and declare their purpose; which is always such as might be expected in a dream.

An acquaintance who lived in the country, informed me of his having walked out into the road for some imaginary purpose in the middle of the night, and though covered only with his shirt, and the weather extremely cold and frosty, had proceeded some distance before he awoke, which happened from his falling over a heap of stones. He was here found by his friends, who, alarmed at the noise he had made in going out, had followed different roads in quest of him.

If the congestion recede partially or unequally from the brain, while it is entirely removed from the parts more immediately connected with the function of loco-motion, the faculties of perception and judgment, and the external senses, will be but imperfectly recovered after the use of the limbs is restored; and this will produce the singular affection above described.

The causes that induce this affection are mental uneasiness, or any secret sorrow preying on the mind; and grief, from its mode of action, in over-distending the vessels of the brain, seems well calculated to produce immoderate relaxation, and leave a degree of congestion in this part of the sensorium, after the tone of the vessels is perfectly restored in others less intimately connected with the perception of moral impressions; as appears to be the case with the cerebellum and spinal marrow.

# CHAP. V.

# DERANGEMENTS

INCIDENTAL TO

## Sensation & Motion.

## SECT. I.

# GENERAL CAUSES OF DERANGEMENT.

SENSATION and Motion may be separately deranged.——In what Organs the Loss of Sensation involves that of Motion; and in what Organs they are not necessarily conjoined.——The Causes from which Derangements may arise reduced to two Classes.——Altered Structure, and altered Circulation.——The former involved in Obscurity.——The latter more within the reach of Investigation.——The Sensorium selected for illustrating the Effects of altered Circulation.——Important Principles to be observed in tracing the Analogy between the Affections of the Sensorium and those of other Organs.——The Analogy and Connexion between different Affections distinctly considered; exemplified in Hypochondriasis and Dyspepsia.

THE intimate connexion between these functions warrants their being treated together, although derangement of the one does not necessarily involve that of the other.

The line of distinction between those organs in which sensation and motion are, and those in which they are not necessarily conjoined, appears to be easily drawn. The motions of involuntary organs depend imme-

diately upon the corporeal feeling of internal irritation; in the organic functions therefore the loss of sensation involves the loss of motion. The action of voluntary muscles, although it may, by a powerful impression, be excited in opposition to the will, yet owes its ordinary exertion to the influence of volition, and requires no corporeal sensation to call it forth; the loss of feeling in voluntary organs does not therefore necessarily involve that of motion.

The various modes in which derangement of these functions may be induced will suggest themselves from the consideration of the nature and origin of the functions themselves.

Sensation is the perception of changes produced on the nerves; derangement may therefore arise from lesion of the organ that first receives and modifies the impression—from that of the nerves that communicate the change induced—or from that of the sensorium that perceives it.

Changes of condition in the organ that first receives the impression of external objects are numerous; some have already been mentioned in treating of the nature of sensation; those for instance proceeding from the frequent application of strong physical impressions,

which impair the delicacy of the organ: thus strong liquors and hot spices, habitually used, in time impair the sense of taste; the frequent use of purgatives induces torpor of the bowels, &c. Changes from injury of the nerve in its course to the organ of sense, are proved to destroy sensation, by the effect of cutting or tying the nerves. Changes from injury in the organ that perceives the impression are seen to impair the faculty of sensation in the effects of paralysis, intoxication, fever, and mental derangement.

Motion proceeds from the contraction of the muscular fibre, induced through the influence of the nervous energy; derangement may therefore arise from lesion of the organ that excites this energy—from that of the nerve which imparts it—or from that of the muscular fibre that receives its influence.

Change of the power of motion, from injury of the organ that first excites or calls the nervous energy into action, is illustrated in the effects of intoxication, paralysis, and injuries of the head. Changes from lesion of the nerves that impart it to the moving fibre, are seen in the effect of cutting, tying, or compressing these nerves; and also in paraplegia from certain mineral poisons, as

lead, when frequently applied to the limbs. Changes of this power from altered condition of the moving fibre, that receives the nervous influence, have been illustrated in the successive stages of muscular action; the phenomena of which present symptoms, first of increasing mobility; then of excessive or painful mobility, with a tendency to spasm; and lastly of diminution or suspension of mobility.

Now the causes of all these changes in the organs that induce, as well as in those that undergo the altered condition essential to the production of sensation and motion, that is in the brain, the nerves, and the ganglia, in the muscles and blood-vessels, may all be reduced to two classes, namely, altered structure, or altered circulation.

Of the causes of altered structure we have a very limited knowledge; being ignorant of the laws by which deposition of nutritive matter and accretion of the animal body are governed. The utmost we can boast of is only a general idea of this function. Thus we conclude, that the blood conveys to each part the materials requisite for its growth, and each part has some how the power of appropriating to itself what is suitable for its nourishment; probably by a modification of phy-

sical and vital action. But with these vague and indefinite notions we can never hope to explain the various deviations from the ordinary process, and the origin of diseases that equally baffle the science of medicine, and the art of surgery; such as cancer, rachitis, scrofulous swelling of the joints, ossification of the arteries, enlargement of the heart, aneurism, and a variety of diseases, the nature of which we fancy we explain by the use of a few technical phrases, totally devoid of meaning.

Of the change of circulation and its causes, something may be learned by a careful examination of the phenomena; and we shall receive ample reward for our labour, when we come to find, that this important function, the derangement of which is the remote cause of by far the greater number of diseases which medicine has to combat, including many of altered structure, is governed by a few general laws, and is to a considerable extent within the reach of medicine, and subject to medicinal influence.

Having formerly ascertained the nature and cause of general participation of the vascular system, in local changes, we may extend our views to some of the phenomena it induces, and try to ascertain the extent of its

influence in promoting derangement of the faculties of sensation and motion, and consequent change of function in different organs

To investigate all the effects of morbid change in sensation and motion, would occupy many volumes, as it must comprise the history of almost every disease incidental to the animal frame. The object of the present inquiry is rather to ascertain the principles than to detail the history of diseases, and this purpose may be as well accomplished by the selection of one or two instances, and a careful analysis of their phenomena, as by accumulating a great variety of examples from different organs, all of which are governed by the same laws, and subject to similar derangement, modified only by the nature of the cause, the structure of the organ, and the function it has to perform.

As the brain, from its control over the general system, is the most important and most interesting organ, it will afford the best illustration of the principles to be deduced; while the complicated nature of its function will render the application of these principles to more simple organs comparatively easy.

After we have analysed the phenomena, and ascertained the influence of altered circula-

tion on the functions of the brain, there are certain points which it will be necessary to keep always steadily in view, in order to prevent confusion in our researches into the relation which the changes in this may bear to those in other organs; or in reasoning upon the analogy that subsists between the derangement of function that will result in different organs, from similar changes in circulation.

The first circumstance which it is important to observe is, that similarity in the change of circulation does not imply resemblance in the change of function that follows it.

Although the laws of circulation may be the same in all organs, it does not therefore follow that there is any similarity between the functions which these organs perform, nor consequently any resemblance between the derangements to which these functions are liable: for example, the function of mind, or thinking, bears no resemblance to that of digestion, though both are dependent upon the state of the capillary vessels, in the organs that perform them: so neither does hypochondriasis, a derangement of the function of mind, bear any resemblance to dyspepsia, which is a derangement of the function of di-

gestion; although it may hereafter appear that they are connected with similar changes in the circulation of their respective organs.

I am disposed to believe that much of the confusion that prevails in pathological reasoning might have been avoided, by proper attention to this simple and almost self-evident proposition. The confusion alluded to apppears, however, in part to result from inattention to another principle, never clearly defined or understood, which it is no less important to bear in mind, in tracing out the analogy between different affections; and that is—

The connexion between the different organs, resulting from their mutual dependence upon each other, and their general dependence upon the state of circulation.

The nature of this connexion will appear sufficiently clear from what has already been offered on the subject of vascular sympathy; where it was shewn, that extensive local changes are liable to induce general participation; and consequently the state of the vessels in one organ cannot be materially altered, without causing a participation in those of others; and hence arises the great difficulty in drawing the line of distinction between the

primary symptoms of a disease, and those which are secondarily induced; or, as it is technically named, between idiopathic and symptomatic affections.

To illustrate these two important principles, we have only to trace, first the analogy, and then the connexion that subsists between the two affections above alluded to, namely, hypochondriasis and dyspepsia; the former an affection of the brain, the latter of the stomach.

The functions of these two organs bear no affinity to each other; or thinking has no resemblance to digestion, but each depends upon the state of its organ for its healthy performance.

The circumstance which immediately determines the condition, and regulates the function of every organ, is the state of its irritability; or, in other words, its degree of susceptibility of impression, and mobility of action; and these two faculties, as we have already seen in numerous instances, and as we shall hereafter find in many more, bear always an immediate relation to the force and quantity of blood circulating in the capillary vessels; irritability being augmented in all organs, within certain limits, by determina-

tion of blood, and diminished by its abstraction.

Now morbid irritability of the brain, from altered condition of its vessels, affects the function of mind, rendering it more susceptible of mental impressions; consequently inducing sudden fluctuations of the spirits, or alternate exhilaration and depression, from the slightest causes; at times, perhaps, an unusual degree of irascibility; or if the change be excessive, complete perversion of reason and judgment may arise from it.

On the other hand, morbid irritability of the stomach, from altered condition of its vessels, affects the function of digestion, also rendering the organ morbidly susceptible of impression; hence eructations, nausea, or vomiting, are liable to arise from slight causes; an intolerable sense of over-distension may result from the least excess in eating; the appetite may at one time be defective, and at another voracious; the secretions may be increased or diminished, and the whole process of assimilation completely vitiated.

Such will be the nature of the effects produced in these two organs by a similar change in the condition of their vessels; and such is the analogy that these derangements of func-

tion bear to each other. But we come now to consider the connexion that prevails between these two morbid affections.

Altered condition of the vessels of the brain is liable to induce participation of vessels of the same class in other organs, particularly in such as are subject to cerebral influence, which is probably more the case with the stomach, than with any other of the organic viscera, as the mind experiences more frequent and immediate perception of the various changes it undergoes, in the different sensations of hunger, thirst, nausea, &c. and more readily corresponds to these impressions. Altered condition of the vessels of the stomach is also liable to produce similar changes in those of other organs, and none are so apt to experience this participation, as those of the brain and heart, for reasons formerly alleged in treating of vascular sympathy.

From this it appears then, that altered circulation of the brain is likely to affect that of the stomach; and change of condition in the vessels of the stomach is still more likely to affect the circulation of the brain; and we here perceive the nature and cause of the alleged sympathy between these organs; or the reason why idiopathic dyspepsia is productive of symptomatic hypochondriasis; and why

idiopathic hypochondriasis produces symptomatic dyspepsia.

The vascular system thus appears, (agreeably to inferences drawn in the investigation of the influence of the passions on the bodily economy) to be the principal connecting medium, through which the state of the body, and that of the mind, reciprocally influence each other.

Keeping these points steadily in view, we may now proceed to illustrate from affections of the sensorium, the precise nature of the changes which its circulation is liable to undergo, and the particular derangements of function that result from them.

The order in which we pursue the inquiry is not very material, nor will it be requisite to enumerate every affection incidental to this organ, nor to mark out accurately the nicer shades of distinction between them, as the following observations are not offered with any reference to nosological arrangement.

Sleep cannot with propriety be regarded as a derangement, but as a natural suspension of the functions, for the purpose of restoring their healthy performance. The most familiar derangement of the mental function, and therefore perhaps the most proper to consider first, is intoxication.

## SECT. II.

# AFFECTIONS OF THE SENSORIUM.

INTOXICATION, its Nature and physical Cause deduced from the Symptoms, Causes, and Remedies.——Insanity; its Relation to Intoxication; to Chronic Inflammation.——Opinions of Chrichton and Haslam.——Appearances on Dissection.——Visible Change in the Brain not always to be expected.——Mode of Treatment.——Syncope; its physical Cause.——Not alwavs originating in impaired Action of the Heart, but sometimes in the Brain itself.——Convulsions.——Cullen's Idea of their Cause examined.——Physical Cause deduced from the Symptoms, Causes, and Remedies.——Whether Collapse may produce them, inquired into.——Why Syncope is often succeeded by Convulsions.——The Operation of other Causes supposed to act by Collapse, explained.

## INTOXICATION.

THE symptoms of this affection nearly exhibit the varieties of mental derangement, age and disposition modifying its effects, as they do in other species of insanity; and the inquiry into its physical cause cannot fail to be highly interesting, from the inference to

which we are almost irresistibly led, that a state of the organ nearly similar must also prevail in the more permanent species of mental derangement. This inference is strongly confirmed by the well known fact, that mania is frequently brought on by habitual intoxication.

From the following considerations, it appears that this state of the organ consists in augmented determination to the minute vessels of the brain, along with accelerated circulation; by which the irritability of this organ, like that of every other under similar circumstances, is morbidly increased. Neither quickened circulation nor congestion can singly produce this effect, or violent exercise would bring it, on the one hand, or hanging down the head, on the other; but the conjunction of these causes seems to be requisite.

In the first place, all the symptoms indicate the conjunction of these causes. The face is flushed, the eyes red, the pulse quick and strong, the vessels turgid, the heat increased, a sense of fulness in the head attends, and head-ache generally succeeds to intoxication.

In the next place, all causes that induce determination to the head, with quickened circulation, give rise to effects more or less

analogous to those of intoxication: thus violent exercise, as dancing in heated rooms; strong emotions of joy, or transports of rage: the delirium of fever, also, which is evidently attended with these circumstances, so remarkably resembles, as to be sometimes mistaken for inebriation.

Thirdly, the causes inducing intoxication must necessarily give rise to quickened circulation, with determination to the head, according to the laws of sensible impressions, and vascular sympathy. These causes are strong impressions, extensively applied to the internal surface of the body, but externally to the minute vessels ramified over that surface. Now we have seen, that strong impressions, external to the vascular system, efface the perception of internal distension, thereby for a moment suspending their contractions, and augmenting the fulness of these vessels. But the faculty of feeling being only diverted, and not destroyed, the moment the distension becomes excessive, this feeling will again predominate; more powerful efforts of contraction will now be produced, and the succeeding effort propel onward a quantity of blood, augmented in proportion to the previous distension; and thus circulation will be quickened. But by the laws of vascular sympathy, exten-

sive local changes in the vascular system soon become general, and the increased action of the vessels of the stomach soon extends to other organs; the brain, for reasons before stated, being one of the first to participate; and thus congestion, with quickened circulation, must result. Accordingly, wine, spirits, and strong fermented liquors, produce quickened circulation, with determination to the head, and therefore intoxication. Why all strong impressions on the stomach do not equally cause intoxication, will be seen hereafter.

Lastly, all causes that remove congestion from the brain, and moderate the force and velocity of circulation, so as to allow the small vessels to recover their natural tone and condition, tend to relieve the effects of intoxication. Thus copious bleeding, especially if the blood be drawn from the region of the head, has this effect. Vomiting, which operates nearly in the same way, and causes a general depletion of vessels, at the same time that it removes the impression of the exciting cause from the stomach, is also a powerful remedy. Wrapping cold wet clothes round the head, and immersing the feet in hot water, are capable of suspending its effects for a time; but not permanently, as they do not remove

the exciting cause from the stomach. Going out of a warm room into the cold air, often at first increases its effects; muscular exertion quickening circulation, as the internal cause continuing to operate, counteracts the constricting influence of cold. Violent pain, and sudden emotions of fear, which have been shewn to induce constriction of vessels, are often known to remove intoxication.

Sleep is the natural termination of this affection, the reason of which is easily explained, on the foregoing principles. Every moving fibre, if exerted to an unusual degree, is susceptible of fatigue; but the vessels, as just stated, have been excited to inordinate efforts of contraction, their natural range of action having undergone a change in the whole vascular system; the mobility of the arteries being increased, and the permanent resistance of the capillaries perhaps giving place to arterial pulsation, by which, symptoms of intoxication are induced. But the force of the impression, now wearing off by the gradual depletion of the stomach, at the same time that the fatigue of over-action disposes the vessels to relaxation, retarded circulation supervenes upon congestion, and sleep is the consequence. During sleep the natural tone of all the vessels is restored, from the capillaries which have

the least, to the arteries which have the greatest, mobility; and each class recovering that range of action which is most consistent with the healthy performance of its function, every organ is restored to its natural condition.

If retarded circulation be prevented from coming on by active exertion of mind or body, and sleep be postponed till intoxication subsides from removal of the internal cause, then a morbid irritability will remain, or an irresistible languor may come on.

Thus then it appears that a state of quickened circulation, with congestion in the brain, is essential to intoxication, as the presence of these causes induces, and their removal takes away, the symptoms of this affection; and this inference is further confirmed by the general laws of sensation and motion, which lead us necessarily to the conclusion, that an altered state of circulation must be attended with altered function in the organ.

The analogy between intoxication and mental derangement is so manifest, as almost to preclude the necessity of adducing any argument in its support.

# INSANITY.

Intoxication arises from a casual and transient cause, where no predisposition prevails, and therefore ceases as the cause subsides. Insanity requires also an exciting cause, but chiefly arises from predisposition in the organ, and therefore remains more permanently after the exciting cause has ceased to operate.

As at different periods of life particular organs are more subject to inflammation, so in different constitutions some one organ is generally of more delicate texture and more susceptible of injury than others: and as external form and feature are observed to prevail in particular families, so the internal structure and organization are also in some measure hereditary; and along with peculiarity of structure, the susceptibility of particular diseases is handed down from parent to offspring.

But a predisposition to organic derangement may be acquired as well as inherited. All causes which accelerate circulation, at the same time that they cause undue determination to the head, if frequently repeated, predispose to insanity; the constant recurrence of over-distension destroying at length

the tone of the vessels, and leaving an unusual degree of mobility. Thus habitual intoxication, and the unrestrained indulgence of the passions, most of which have been shewn directly or indirectly to produce the effect above mentioned, in time alter the state of the vessels, and become predisposing causes; at the same time that a single debauch, or a sudden transport of rage, may instantly bring on an attack of mania, acting as exciting causes where predisposition prevailed.

As maniacs are at times gloomy and desponding, at others elated and impetuous, some have inferred that these opposite effects indicate a contrary condition of the vessels of the brain, and that if they are over-distended in the latter, they must be collapsed in the former. But this conclusion appears to be erroneous; as great a difference prevailing between acute and chronic inflammation, yet the vessels are over-distended in both, and both are relieved by the removal of congestion; modifying circumstances producing the difference of symptoms from a state of vessels in some respects similar in each. We see in the effects of intoxication varieties as remarkable as those of insanity; one person is boisterous, another sullen and morose; but as the one is attended with a pleasing sensible impression,

voluntarily applied, and the other as often arises from painful as from grateful feelings, so the symptoms of intoxication more frequently exhibit exhilaration than gloominess. Most frequently, however, these effects are combined, or alternate with each other, and this is equally the case in intoxication and in mania; the passive stage of inebriation coming on, and exhibiting marks of sullenness, depression, or unusual irascibility, as the active stage subsides.

The opinions of two of the most eminent writers who have lately treated of this interesting disease, respecting the physical cause of insanity, though expressed with considerable caution, claim particular notice.

Dr. Crichton conjectures, that all kinds of madness are attended with altered circulation of the brain; and he shews that organic injury of other kinds, as tumours, abscesses, ossification, and serous effusion, may occur without producing mental derangement; but in all cases where the general circulation is disturbed, he conceives derangement of function to attend. Now if it be considered that local injury in other organs does not always induce lesion of function, until plethora or the inflammatory disposition come to prevail, and then it becomes an exciting cause to in-

flammation, as in tubercles of the lung s;so we may conceive similar effects to arise from altered structure in the brain, which becomes an exciting cause of organic derangement at particular times only, and under particular circumstances.

Mr. Haslam, in his excellent work on the same subject, shews that marks of undue determination to the small vessels of the brain, were visible on dissection in eighteen out of the first twenty cases he relates; and though he does not decide that this was the cause of insanity, he ascribes the altered function to physical changes in the organ, and leaves the reader to judge of their nature, from the important facts he furnishes him.

It is not, however, to be expected, that visible changes may always be discovered in vessels which are too minute to admit ocular proof of their existence. Concussion of the brain often causes death, without any traces of physical derangement being perceptible on dissection. After the conjunctiva of the eye has been affected with inflammation, a laxity of the white vessels remains, apparent only in the watery pellucid appearance of the organ, but sufficiently evident in its effects, which occasion a morbid susceptibility of impression, and render the part subject to fresh

inflammation, from exposure to causes otherwise too trivial to affect it: so changes may exist in the minute vessels of the brain that produce important derangement of function, yet elude the search of the dissector.

As in some kinds of insanity the affection is confined to a particular class of ideas, the impaired tone of the vessels of the brain remaining, after the more active stage has subsided, may be insufficient to excite derangement from ordinary impressions, and only productive of injury when any casual association brings on the train of ideas connected with that class of moral feelings whose influence is become too powerful.

As the weakness of these small vessels which remains in any organ after inflammation is seldom to be removed by local applications, but requires constant care in avoiding a repetition of the exciting causes until time has been allowed for nature to restore their tone; so neither can we expect by local application to remove the morbid irritability of the more delicate and less accessible organ of mind. Local derivation may often be employed with advantage as an adjunct to other means, but this alone can seldom effect a cure without what may be termed moral treatment, being required in addition; which consists

chiefly in avoiding every cause likely to produce those feelings or associations which make a powerful impression on the mind, and induce determination to the brain. The next derangement of function I propose to consider is

## SYNCOPE.

Before I proceed to inquire into the nature of this affection, it is necessary once more to notice the opinion very commonly received, though obviously erroneous, which is, that uneasy sensations, and even important derangements of function may arise, without any change either of structure or circulation in the organ affected; thus head-ache, syncope, and convulsions from impressions on the stomach, are often referred to nervous sympathy, implying that no physical change exists in the organ affected. But this assumption, founded on the absence of any visible change, apparent on dissection, is unwarranted; changes which are too minute to be visible, in the condition of the vessels, being capable of producing, as already shewn, very material derangement of function; and in parts confined by bone, the distension and pressure arising

from increased afflux of blood, may excite the most painful sensation.

So long as the term sympathy was employed only to express an unknown principle, it could not be well explained, how impressions on the stomach should induce head-ache, intoxication, sleep, or convulsions; but having in part ascertained the nature of that principle, and developed the the laws by which it is governed, we find it afford a clue to the explanation of these, and many other important phenomena; and the cause of syncope will derive considerable light from the same source.

Every derangement of function must have its ultimate seat in the organ that performs that function; and as those of mind and voluntary motion belong to the brain, syncope, which is a sudden failure of those faculties, must consequently have its seat in the brain; and the precise cause inducing it will be found to be abstraction of blood from the head. As the heart is the organ whose office it is to send blood to the head, a diminution of its action is the most common cause of this abstraction; whence, with an inaccuracy of expression, too common in medical reasoning, the heart is frequently termed the seat of syncope; but independently of the impro-

priety of such an expression, which is no less absurd than it would be to say, that head-ache is sometimes seated in the stomach, it will be shewn, that syncope does not always proceed from diminished action of the heart, but is sometimes attended with an increased determination of blood to that organ; two causes presenting themselves by which the vessels of the brain are liable to experience too great a depletion, namely—impaired impulse in the blood, and increased resistance in the vessels. In both cases, however, diminution in the force and quantity of the blood circulating in the brain is the immediate cause of syncope, as appears to be established from the following arguments:

Every symptom present indicates the want of blood in the region of the head; such as failure of the strength and suspension of the mental faculties, paleness of the face, and shrinking of the vessels, with relaxation of the pores, inducing cold sweat.

In the next place, all the causes that give rise to it are calculated to produce abstraction of blood from the brain. The most remarkable of these is hæmorrhage, the operation of which is, perhaps, less simple than it appears to be; the following points demanding our attention, in order to obtain a distinct idea

of it:—The distending force of the blood is equally and simultaneously applied to all parts of the system, and likewise the corresponding effort of contraction is equal and simultaneous in all, both from the uniform application of the exciting cause, and the general sympathy of the vessels: by these means, an equal distribution of the blood is produced, according to the area of each class of vessels. But if we now suppose the resistance opposed to this contractile force of the vessels to be partially withdrawn by abstraction of the blood, an immoderate degree of contraction will result in the vessels of that part from which the resistance is suddenly removed. This effect is seen in a remarkable degree in the contraction of a divided artery, which suddenly shrinks as the blood flows, from the size of an ordinary man's fore finger to the area of a crow-quill; an effect that may be witnessed at every amputation. The veins and capillaries likewise shrink from the partial removal of the internal resistance, as the paleness and cold sweat produced by immoderate vomiting andpurging seem to indicate; being the consequence of the sudden depletion of the capillaries of the internal, sympathetically communicated to those of the external surface, belonging to the same class of vessels.

Now the immediate and local effect of depletion, being an increased contraction in the vessels from which the resistance is suddenly removed, the function primarily affected will depend upon the part on which the cause immediately operates; in the stomach it may contribute to promote vomiting, in the intestines purging; in the brain syncope may be the effect, and the general participation of all vessels of the same class in extensive local changes may cause all these organs to be affected together to a certain extent; but the organ that first participates may vary according to the part from which the internal resistance is first removed. But as the whole vascular system soon participates, the ultimate effects of hæmorrhage, if considerable, will be always the same, namely, syncope. Another cause of fainting is rising suddenly out of bed, after the tone of the vessels has been impaired by fever, confinement, or long continuance from any cause in the horizontal posture. The sudden change throwing a greater pressure on the sides of the vessels than they have been accustomed to bear, a more considerable effort is required to send the blood to the head than they are able to make, and syncope therefore results from diminished afflux to the brain. Simply standing

in the erect posture for any length of time, without muscular motion to assist in propelling the blood to the heart, also produces syncope in the same way. The vessels become overpowed by the continued pressure of the column of blood, and at length relax from fatigue, and thus fainting supervenes.

In all the preceding instances, the vessels of the brain may be only indirectly affected, through changes originating in other parts; but in the following cases, they seem to be primarily constricted, being the original seat of the impression:—These are mental emotions, which appear to act immediately upon the brain, and subsequently upon other organs. Of these, the most remarkable in producing syncope is fear, which was shewn to cause a direct constriction of vessels, whereby the blood is expelled from them; and if the cause be sufficiently powerful, the brain is deprived of the means which are essential to the functions of mind, and consciousness is therefore suspended, and syncope induced. But so far is this effect from being the result of impaired action of the heart, or derivation from that organ, that a violent palpitation, and a sense of pressure at the precordia from undue determination to the larger vessels attend; while the re-action that suc-

ceeds, the instant the constriction subsides, explicable upon no other supposition, proves the nature of the cause, inducing both the palpitation and the sense of oppression. Another mental impression that occasionally gives rise to fainting, is strong aversion, or disgust; which also appears to owe its influence to the same principle that operates in fear, namely—an alliance or association with certain bodily feelings: thus the sight of a surgical operation, or of a person losing blood, may cause fainting, from association with the feelings supposed to attend; ideal feelings operating in a manner analogous (as before shewn) to actual pain, and constricting the vessels. In the same way, the sight of any substance that is nauseating, causes sickness at the stomach, by too strongly directing the attention to imaginary impressions on the organ; the sight of an open ulcer may, in the same way, cause sickness or fainting. Syncope is also produced by certain odours, probably owing to their affinity to tastes; and some sounds have a similar effect, which evidently owe their influence to association. Thus sounds which awake the idea of scraping the teeth with the sharp edge of a knife, or of scratching the nails over the rough surface of a stone wall, or hearth, excite the

corresponding sensations, and from their analogy, both are said to set the teeth on edge. In the same way may the operations of all mental impressions, that give rise to syncope, be referred directly to their influence over the circulation of the brain.

Thus it appears, that every cause of syncope is calculated to impair the force and quantity of blood circulating in the brain; and we shall next see, that every remedy that relieves it, and restores the functions of mind and motion, is adapted to the removal of this cause.

When fainting arises from diminished impulse in the blood, as in rising up after long confinement to bed, the most effectual remedy is resuming the horizontal posture, which supersedes the necessity of strong arterial action, by removing the resistance of the column of blood; when the person falls to the ground from loss of strength, the disease finds therefore a remedy for itself. When constriction of vessels primarily induced is the cause of syncope, as from fear, it is removed by any strong impression external to the vascular system, as unexpectedly sprinkling cold water in the face, or applying volatile salts to the nose; external impressions impairing the efforts of contraction, or causing

direct relaxation of vessels, as before shewn. —Thus then we see, that every symptom attending, every cause inducing, and every remedy removing this affection, bear testimony to its nature. I next proceed to another affection, no less interesting, and still more important in practice, which is convulsions.

## CONVULSIONS.

Were it asserted that any particular symptom must always arise from the same ultimate cause, such an assertion would certainly be inadmissible from our limited knowledge of the animal economy. But when we see the same effect proceeding from causes apparently opposite, we are certainly unwarranted in assuming, that both are ultimate causes, as there may be intermediate links of which we are not aware. Thus when Cullen states, that undue determination to the brain, and excessive abstraction of blood from it, both produce convulsions, the fact from which he argues cannot be denied, which is, that syncope is frequently attended with, or succeeded by them; but when he assumes, that the abstraction of blood is the immediate cause of both, he proceeds a step farther than

his premises warrant. He should first have ascertained whether collapse itself could in any way produce a contrary change, and subsequent determination to the brain; a point which either appears to have never occurred to him, or to have been answered in the negative without sufficient proof. The terms excitement and collapse, which he employed, are too indefinite to throw much light upon such an investigation; and it is not perfectly clear what precise idea he attached to them. I shall therefore substitute others less likely to mislead either my reader or myself by their ambiguity.

I have before stated my reason for supposing that the cerebrum is more immediately instrumental to the function of mind, and the cerebellum to that of motion; but as both are evidently, if not always equally deranged during convulsions, and as one can hardly be supposed to suffer material changes without the participation of the other, I shall speak of the encephalon in general as the seat of derangement in convulsive affections.

In conformity with the plan already adopted, I shall state my inference before I adduce the facts from which it is drawn, in order that the reader may the more readily detect any fallacy in the reasoning.

Among the effects of altered circulation in the encephalon, we have seen that languid circulation, with moderate congestion, induces sleep; accelerated circulation, with determination to the brain, intoxication, and the various modifications of mental derangement; derivation, or excessive abstraction of blood from the head, syncope; and from the following considerations, it will appear that immoderate determination, or excessive congestion, with active circulation, is at least one cause of convulsions. How far an opposite state of vessels, or collapse, is capable of producing the same effect, will be afterwards considered.

In the first place, all the symptoms preceding and attending convulsions distinctly indicate the presence of congestion, gradually increasing, from its first commencement, till it produces a total suspension of the functions of sensation and motion, and terminates in a state of stupor or coma.

A very common precursor of a convulsive attack is the sound of unusual noises in the ears, as a continued buzz or ringing. The most probable explanation of this symptom is, such a determination to the organ as morbidly increases its sensibility, rendering perceptible a multitude of sounds, otherwise too minute

to be heard, and therefore causing a confusion of noises like the distant ringing of bells, or falling of water, or sometimes like the rolling of carriages; and as the determination increases this confusion becomes so great, as to destroy the power of distinguishing sounds. Vertigo is a frequent precursor of convulsions; the proximate cause of this symptom may not perhaps be satisfactorily accounted for, but its connexion with determination to the head appears from its always accompanying intoxication. Suffusion of the face, increasing sometimes to a purple or blue tinge, more strikingly denotes excessive congestion in the vessels. The torpor which comes on as the convulsions go off, from the congestion subsiding, and the force of circulation abating to that degree which constitutes sleep, further confirms the inference; the comatose state must however be regarded as still a morbid, and not a natural sleep. Lastly, the paralysis that frequently succeeds to convulsions, is a further proof that a state of excessive congestion preceded and gave rise to the effusion, which seems, from morbid dissections, to be the usual cause of paralytic affections.

In the next place, the causes that give rise to convulsions, are calculated to produce excessive determination to the head.

One of the least equivocal of these is, a splinter of bone, or depression of the skull; from which the most important deduction to be drawn is, that this is not the ultimate cause of the affection, as it frequently remains for a long time without producing this effect, acting often periodically, or under particular circumstances, as when the circulation has been accidentally increased by some unusual effort; we can therefore only regard this as the exciting cause, contributing with others to produce that condition of the sensorium which is the immediate cause of convulsions; and it is our business to inquire what constitutes that state, and why it occurs only at intervals when the exciting cause remains always present. Now in a former part of the inquiry we found that irritating causes applied externally to the vascular system, caused local congestion and deranged circulation, and irritation must necessarily be excited by a splinter, or depression of bone acting upon the surface or membranes of the brain; congestion is therefore the effect that must follow from this cause. But we have yet to ascertain why this effect does not always attend, or at least in a sufficient degree to excite convulsions; and analogy here affords us considerable assistance in the facts admitted by almost every pa-

thologist, that irritating causes are constantly found to have remained present in different organs without inducing general derangement, or even local inflammation, until the irritability of the system has been increased to a degree to render it more than usually susceptible of their impression. This is exemplified in tubercles in the lungs, chronic abscess in the liver, in various affections of a schirrous nature, and in numerous instances in which altered structure has taken place, or foreign substances have been introduced into the system. The causes admitted to increase the general irritability are chiefly, plethora, debility, and the inflammatory diathesis, which last seems in fact to mean no more than a permanently increased force of circulation. Now the irritability being locally increased by plethora, the general tendency of the vascular system to sympathize in a local inflammation, is also increased by those causes which render it more susceptible of local derangement; and as convulsions are evidently a general affection of the sensorium, deranged circulation, or excessive congestion in this organ from sympathy with the local derangement, appears to be their immediate cause. Tumours, abscesses, ossification, &c. are in like manner causes of local irritation in the brain, capable, under dis-

posing circumstances, of producing such a general derangement and congestion in the organ, as may occasion convulsions. In short, it appears then, when convulsions arise from irritating causes, applied to the brain, that they are not the immediate consequence of the local irritation, but of the general derangement of circulation, sympathetically arising from that irritation; and the tendency to that general participation is increased by plethora, debility, or any cause that augments the irritability of the vascular system.

When convulsions arise from any of the foregoing causes, as the brain is the primary seat of the disease, the affection is termed idiopathic; but they are also liable to occur from a multitude of causes applied to distant parts, which appear to act through the medium of vascular sympathy.

The least equivocal of these is perhaps a large dose of laudanum taken into the stomach, which was proved in the experiments already stated, to act by determination to the head, and not by any peculiarly deleterious influence communicated by the nerves to the brain; as the effect no longer results after the heart has been taken out, but death is induced, preceded by no convulsions. That it does not arise from absorption of the opium, and its direct

application to the brain was proved by the same experiment; and the suddenness of the effect in the instances alluded to was incompatible with the operation of this cause. That vascular sympathy alone without the application of any deleterious substance to the brain is capable of inducing convulsions, when the impulse of the blood remains unimpaired, or the circulation not suspended, is still more distinctly proved in the instance of worms in the intestines, which are known from the most extensive experience to produce this effect; but like other causes of irritation at times only, and under disposing circumstances. The irritation produced by worms may arise partly from their motion, and partly from their gnawing the mucous membrane of the intestines, which appears from morbid dissection to be sometimes perforated by them. The influence of vascular sympathy is seen also in the irritation of teething, the most common cause of convulsions in children. The vicinity of the gums to the brain may help to account for the ready participation of that organ in their affection; and tendency to plethora in the head increasing the irritability of that organ during infancy, shews why convulsive affections are more easily induced at that period of life. The sym-

pathetic affection of the vessels of the brain is of course materially different from the inflammation of the gums that gives rise to it, as is sufficiently evident from its transient duration; it is probably somewhat analogous to the sudden suffusion of the vessels of the face, which visibly attends the convulsive paroxysm, an effect analogous to what is familiar in the instance of blushing; the resistance of the surrounding bone causing perhaps an injurious pressure in the encephalon, from this sudden determination, while no dangerous consequences result from the same cause in parts which have liberty to expand. But my present argument only goes to establish the existence of this determination, without explaining its mode of operation; and in every instance hitherto mentioned, I think the inference fully warranted, that sudden and excessive determination to the head, agreeably to Dr. Cullen's opinion, and that of the older writers, is the most common cause of convulsions. I shall proceed next to the remedies that are found to remove this affection.

The remedies removing convulsions attest its nature less distinctly than the symptoms attending, and the causes inducing it, as unfortunately this affection, except when symp-

tomatic, is rarely within the reach or control of medicine. When the brain is the primary seat of the disease, all that medicine can do is to obviate those causes which tend to increase the general irritability, as debility and plethora; and so far the remedies accord with the preceding view of the nature of the affection, evacuants and tonics being the means almost exclusively resorted to. When it is symptomatic the cure depends upon the removal of the primary cause, and verifies the maxim of Celsus, that he can best cure diseases who can best discover their cause. If irritation in the gums gives rise to it, lancing them will have the effect; if acrimony in the intestines, antacids, purgatives, and change of diet may be required; if worms be the origin, their removal is indispensably necessary.

But these remedies, though of the first importance in a practical point of view, as being the only means of radically removing the disease, throw less light upon what is termed the proximate cause, than others employed only to palliate symptoms, or suspend the convulsive paroxysm. Of this nature is the warm bath, the efficacy of which in moderating the force of convulsions, seems to depend upon its inducing immediately a general relaxation of

the vascular system, so as to cause an uniform distribution of the blood, which tends to the manifest relief of a local congestion. The propriety, however, of employing the water very warm, of continuing its application for a long time, and perhaps of immersing the patient entirely into it, appears very questionable, as they all ultimately induce determination to the head, by increasing the force of circulation; the semicupium, or a more partial immersion, which acts first by derivation, seems a less ambiguous remedy. Another remedy, the safety of which is still more doubtful, as its use appears exclusively admissible in one species of the disease, is the cold affusion, or throwing cold water unexpectedly over the patient. This effectually suspends that species of epilepsy which arises from the influence of strong mental impressions; the sudden constriction of the vessels communicating from the external to the internal surface tends to remove the congestion; but the surprise or alarm excited by the sudden affusion, which also tends to produce constriction in the vessels of the brain, is probably more efficacious in relieving congestion.— The safety of this remedy, in other cases where it does not as in the foregoing instance, remove at once both the immediate and the exciting

cause, must appear extremely doubtful, as excessive constriction is succeeded by a proportionate relaxation in the same vessels. Another remedy, and perhaps one of the most decisive in checking convulsions, though by no means indiscriminately proper, is bleeding; the operation of which, in relieving congestion does not appear very ambiguous. There is one circumstance often attending the employment of this remedy, that appears at first somewhat paradoxical; which is, that in bleeding a person in a comatose state, convulsions sometimes come on, as the coma recedes, which admits of explanation as follows:—When action ceases in the vessels of the brain, and immoderate congestion is attended with passive relaxation, sleep or coma results; but when action recommences, and excessive congestion is accompanied with active circulation, convulsions arise. Now relieving the vessels of part of the load that oppresses them may restore their power of action; and as the congestion does not instantly recede, these may for a short time subsist together, and produce convulsions, which explains the paradox.—It may be further remarked, that blood is not always taken directly from the vessels of the brain; and the power of resistance will be first restored in the vessels of the

part from whence the distending force is first withdrawn, or the oppression first removed. But a greater force will be required, again to distend these vessels than is required to keep those over-distended which are so: if this were not the case, no benefit could ever result from local bleeding in local inflammation. Now the immediate effect of this will be an increased pressure upon the vessels that remain over-distended, in consequence of the additional resistance the blood meets with in those parts which have recovered the power of action; and as this change is likely first to occur towards the surface from whence the blood is drawn, the primary effect of bleeding will be to restore active circulation, and augment congestion in internal parts. To obviate this objection to its employment, as a palliative, blood should be taken as directly from the brain as possible; or perhaps the simultaneous use of the warm bath may counteract the partial constriction.

So far we have seen that all the symptoms attending convulsions, and the remedies removing them, confirm the inference that this affection ultimately depends upon a sudden and forcible determination of blood to the head; and that all the causes which we have yet considered, are calculated under disposing

circumstances to produce this effect, and that it is at this time, and then only that convulsions proceed from them; which would lead to the conclusion, that this is the ultimate cause of this peculiar derangement of the functions of sense and motion.

But we have yet another class of causes apparently of an opposite nature producing the same effect, which leads to the inquiry whether they may also result from excessive abstraction of blood, or whether a subsequent change takes place previous to their occurrence. The fact that syncope and convulsions often alternate with each other is indisputable, but that symptoms so opposite arise from the same immediate cause should not be admitted without a minute and careful analysis of the phenomena.

The connexion between syncope and convulsions may derive much light from the principles deduced in Bichât's scientific inquiry into the doctrines of asphixia.

In cases of suspended animation he proved experimentally, that the powers of action do not cease simultaneously in the brain, lungs, and heart, but in different succession according to the function primarily suspended; as one organ is more, and another less immediately dependent upon others for the continu-

ance of its action. The brain, heart, and lungs are all ultimately dependent upon each other, but not immediately in an equal degree. Respiration depending directly upon the sensorium, ceases the instant it is destroyed; but the heart being less directly under its control, continues to beat for some time if blood be sent forward to distend it, and venous blood be not infused into its coronary system; which was supposed by Bichât instantly to destroy its irritability. The function of the sensorium depending directly upon the state of its circulation is instantly affected by altered action of the heart, and suspended by arresting the progress of the blood.

Now when convulsions proceed from syncope, produced by hæmorrhage, the following circumstances would appear to take place. The abstraction of blood from the brain will first suspend the function of this organ, and cause syncope; but respiration depending upon the sensorium, will be interrupted, and congestion in the lungs be the consequence. From this cause the blood will be obstructed in coming from the heart, and a greater congestion be induced in the larger vessels; and the action of these organs being independent of the sensorium, will be roused to more active exertion. Re-action thus excited will prove a

remedy to syncope, augmenting the impulse of blood going to the head, and if powerful enough may occasion a determination to the brain sufficient to give rise to excessive congestion, and thus will convulsions succeed to syncope. The influence of suspended respiration in augmenting determination to the head, may be proved experimentally by holding the breath, which soon produces turgescence in the vessels of the face.

When convulsions arise from syncope produced by fear or strong mental impressions, as aversion, or horror, the cause of congestion is still more obvious. The primary constriction of the vessels of the sensorium immediately predisposes them to subsequent relaxation, at the same time that re-action of the heart and arteries is more strongly roused by the sudden accumulation of blood about the præcordia, indicated by the palpitation attending; and thus convulsions appear more likely to succeed to syncope from these causes. Similar effects are also known to arise in some cases from strong impressions on the organ of smell, which may be supposed to proceed from the physical impression external to the vessels of the mucous membrane exciting immoderate congestion; or an opposite effect may result from mental associ-

ation, the effect, as Cullen suggests, then depending more on a particular aversion than the physical action of the cause applied. But having shewn how those causes which primarily induce syncope subsequently may produce convulsions, the same explanation is applicable to all ; and it appears sufficiently probable that the ultimate cause of convulsions is always the same, namely immoderate determination to the sensorium.

As the cerebrum is supposed to be more immediately necessary to the function of mind, and the cerebellum to that of motion, we may conceive that one is sometimes affected in a greater degree than the other ; whence some persons are known to retain their consciousness in fits of epilepsy, and especially in incubus, which seems to be an approximation to that affection.

# CHAP. VI.

# PHYSICAL MEANS

OF MODIFYING

## Sensation & Motion.

## SECT. I.

# ACTION OF MEDICINES IN GENERAL.

REMARKS on the Classification of Medicines.——Inquiry into their Operation, how it should be conducted.——Whether Physical Agents act solely by Irritation.——Inadequacy of this Hypothesis to explain the Phenomena, illustrated in Contagion. Medicines appear to act on a two-fold Principle.——The Physical Changes they produce, and the Feelings that arise from them.——These Principles considered in Relation to Sensation and Motion.——Physical Cause why Permanency and Mobility of Action are inversely as each other.——Nature of the Physical Action of Drugs, ascertained experimentally.——Nature of the Organic Feelings they excite, how ascertained.——Influence of these two Principles in modifying each other.

AS nature is observed to effect a variety of purposes by comparatively few means, it seems to have been supposed that generalization of properties was necessarily the first step towards explaining the action of different substances on the living body; and so far has this principle been carried, that the nature of diseases has been frequently inferred from the supposed nature of the remedy.

Classification of medicines has been generally founded on some property possessed in common, while specific differences of far more importance in practice have been often overlooked. The following comparison between two substances whose title to arrangement under the same class has engrossed much attention and excited considerable controversy, may serve to illustrate the truth of this remark; and at the same time shew what advantage is likely to accrue to the science of pathology from the use of the generic terms stimulant, sedative, and narcotic.

The substances whose effects I propose to compare are digitalis and opium. Some contend that they are both sedative, others that they are stimulant, while many deem them decidedly narcotic.

Opium is one of the most powerful means employed for allaying vomiting; digitalis on the contrary is very powerful in exciting it, and has occasionally been used as an emetic. —Opium is the most effectual soporific we possess; digitalis has no such property. Opium locally applied allays pain; digitalis does not. Opium renders the pulse full and strong; digitalis small and weak. Opium often increases for a time the strength and spirits; digitalis induces depression and debility. Opium

diminishes the secretions and excretions; digitalis increases them. Opium is used in some countries as an article of luxury; which digitalis never was nor is ever likely to be.

The same kind of comparison might be made between other substances deemed still more analogous in their properties; and differences no less striking would appear. In fact, the very use of the terms is pregnant with danger, as those who want sufficient judgment or experience, are naturally led from similarity of name, to expect community of properties, and indiscriminate practice too often results from this expectation.

More practical benefit would probably accrue from the perfect knowledge of the nature and action of a few articles in common use, than from the most accurate classification of the whole materia medica that is ever likely to be formed. The only one, in the present state of our knowledge, that seems unexceptionable, is that derived from the change of function immediately induced, without any reference to the manner in which it is supposed to be effected; such as emetics, cathartics, diaphoretics, diuretics, &c., these effects being produced by medicines of an opposite nature, and different effects constantly resulting from the same medicine in different doses.

It is not, however, to be inferred, that the inquiry into the nature and action of medicines is either unprofitable or the knowledge unattainable; but that inquiry must be conducted upon very different principles to those now stated, before either advantage can be derived from it, or success attend it.

It seems almost self-evident, that the manner in which any particular function is deranged can never be understood, so long as the function itself is not understood; and the manner in which any particular derangement of function is relieved can never be exactly ascertained, till we are acquainted with the true nature of that derangement.

The first step then towards explaining the nature of disease, is to acquire correct views of the nature of the functions; and the first step to a knowledge of the operation of remedies, is to attain an accurate idea of the nature of the disease; and not by generalizing the properties of drugs, to infer the nature of the disease from the supposed properties of the remedy.

Of the vital functions and the nature of the derangements to which they are subject, we have already treated at some length, more especially of those induced through the medium of altered circulation; but there is an-

other class, as before stated, the obscurity of which seems at present to baffle research, viz. derangements of structure. Those of circulation are, however, of more immediate importance, both on account of their being more within the reach of medicine, and of their being the most frequent cause of diseases of structure: to these, therefore, our attention will be immediately directed.

The influence of sensible impressions in deranging the vital functions has been already investigated; and we have found, that those which are pleasing induce decreased, and those which are painful increased efforts of contraction, if internal to the vascular system; but both cause direct relaxation, if external to the vessels. We have likewise deduced this important law, that the vital powers being limited in their nature and extent, whatever inordinately augments the action of any organ can only transiently produce that effect, a degree of relaxation always succeeding proportionate to the degree of previous over-action. The duration of the increased action varies indeed according to the permanency of action peculiar to the organ; but the influence of the exciting cause ceases there, if that influence depend solely upon its stimulating effects.

But are we warranted in assuming, that this is the only mode of action in medicinal substances? Unless we can explain all the effects of medicine upon such a principle, the assumption certainly seems inadmissible; and that the laws of sensible impressions are not adequate to this, the following considerations may satisfy us :—

If substances applied to our organs act only by their stimulus or the irritation they occasion, their effects should bear some relation to that irritation; but the fact is often the reverse of this. Thus opium, which excites little sensible impression, produces more important derangement of circulation when applied externally to the vascular system, than Cayenne pepper, which produces in equal doses a sensible impression far more powerful. The laws of sensible impressions may explain how irritation, external to the vascular system, induces such derangement of circulation as to excite intoxication; but these laws cannot explain why all substances that produce the same or a greater degree of irritation, do not also cause intoxication. Thus strong bitter infusions do not cause intoxication like spirituous, vinous, or other fermented liquors. If the laws of sensible impressions can explain how bark may check the paroxysms of

an intermittent, the same laws cannot explain why bark is so much more efficacious than any other vegetable bitter in curing that disorder. If foreign matters applied to the body have no action but what arises from the irritation they excite, the laws of irritation should afford some explanation of the various effects that result from different poisons, and not only those derived from the vegetable and mineral, but likewise those from the animal kingdom. Thus they should explain, why the matter of cow-pox and that of small-pox, though applied to the same part, and exciting apparently the same degree of local irritation, produce diseases so totally different. They should also explain, or at least enable us to conceive, why one produces a disease that is contagious, the other one that is not so. But they should likewise offer some reason, why matters derived originally from the living animal body have the exclusive property of propagating themselves in the system, and generating more matter similar in its effects, and retaining its own distinctive character, though transmitted to thousands.

But the laws of irritation and deranged circulation afford no clue, as we have seen, to this explanation; and some other principles must be sought for before we can form any

conception of the nature of the changes producing these phenomena. The cause exciting them we know to have been the introduction of a small portion of matter similar to that afterwards propagated in the system; and though we may not be able on any principles to account for the action giving rise to the changes produced, we may conceive from analogy the possibility of explaining perhaps the nature of the changes effected, in a more advanced state of knowledge, and form a probable conjecture at the reason of the phenomena attending them.

The antients illustrated their notion of these changes by comparing them to the process of fermentation; an illustration that first became ridiculous, when the idea of analogy was relinquished and that of identity contended for.—However untenable the arguments in favour of identity may be, those adduced in support of the analogy are certainly striking, and seem hardly to merit the ridicule they have incurred.

The analogy rests upon the changes induced in the circulating mass; the general disturbance of the whole system attending those changes; the separation of a portion of new matter different from the common mass, and similar to that introduced into the system; the

effluvia or exhalation thrown off from the body during the production of these changes; and the remarkable fact, that in most instances these changes cannot be induced a second time.

The arguments urged against these are,—that there is no perceptible change in the blood after this process; to which it may be answered, that we may not be able to detect these changes, as we are unable to detect the presence of contagion itself. It is objected, that the blood is continually renewing, and its changes could not be permanent; to which it may be answered, so are the solids, and the changes must be somewhere that prevent recurrence of action. This objection will certainly not be deemed valid by those who are at all acquainted with the laws of chemical affinity; the balance of affinities being once destroyed, a new arrangement may take place, and cause different particles to be continually assimilated and rejected from what would have been, had this change never taken place; and thus the effect may be permanent, though the whole mass of solids and fluids is renewed an hundred times. It is objected, that the blood does not communicate the disease; if true, it may be urged, that the yeast rather than the liquor excites fermentation. But after all, this

supposed analogy, which, allowing for the difference between living and inanimate matter, must certainly appear rather remarkable, is more a matter of curiosity than utility; and the important inference to be drawn from it is, that some other laws, different from those of simple irritation, must operate in the production of the changes proceeding from, and the phenomena attending this admission of an inconceivably small portion of foreign matter into the system.

That the diseases induced by this matter, and the subsequent changes in the constitution, depend upon its slow and gradual assimilation with the body, and not upon the disturbance of circulation which its immediate irritation excites, must be inferred from its effects not directly following the application, but arising only after the matter has had time to combine with and assimilate itself to the body; being contrary to the effects of sensible impressions, which generally decline from long continuance, and are most powerful at first; the degree of perception they excite, as formerly stated, depending more upon the novelty and rapidity, than upon the particular kind of change they occasion. This inference likewise rests upon the peculiar nature of the symptoms produced, which are wholly inexplicable

upon the laws of sensible impressions; as no peculiar action of vessels can explain, why one species of matter produces cow pox, another small pox; why one causes a disease that is contagious, another one that is not so; why one species of matter produces a disease, the effects of which remain a permanent security against its recurrence, and another leaves the body more liable to its attack than before.

These are effects which can only be referred to the physical agency of the specific matter applied, and not to the vital agency or change of action in the vital functions produced by unusual irritation. On the contrary, it seems in a great measure peculiar to animal contagions to excite little irritation, because they combine slowly and imperceptibly with the system; whereas vegetable and mineral poisons are productive of this effect in a very remarkable degree, but are wholly destitute of those characteristic effects just stated to attend some animal poisons. These principles may hereafter assist in explaining, and be also more fully illustrated in the different symptoms produced from animal and vegetable effluvia, the former exciting little, and the latter much greater irritation; and may perhaps lead us to the reason, why one kind of effluvia causes a disease that is con-

tagious, the other one that is not so; why one leaves the body less, the other more liable to a recurrence of the same disease; why one is, and the other is not attended with a periodical intermission of the symptoms, &c.

If ever we are to arrive at the knowledge of the effects of foreign substances acting upon our bodies, I conceive the following to be the principles on which that explanation must be sought for:—

Every individual substance capable of acting upon our organs has some physical property exclusively belonging to itself; thus no two have exactly the same taste or smell, and no two have exactly the same medicinal effects.

This peculiar property acts uniformly, though by no means equally upon every organ susceptible of its impression, and the changes it induces are as constant and unvarying as the nature of the substance itself. These changes are the cause of the different sensations it produces; and, as the changes are invariable, so the sensations arising from them, unless the organ be defective, are invariably the same in every individual; thus sugar is uniformly sweet, lemon acid, and quassia bitter; these sensations consisting in the perception of the physical changes pro-

duced on the organ by these respective substances.

The action which gives rise to these changes I term the physical action, as it proceeds from the physical properties of the substance applied; and this term I shall employ in contradistinction to another, which is next to be pointed out.

As every organ supplied with nerves appears to possess the faculty of feeling, although the mind is not necessarily conscious of the impression, so I conceive every physical change that is sufficiently rapid or powerful in its production, to give rise to some degree of feeling in the organ; and as every involuntary motion proceeds from a feeling excited, so I conceive every change of feeling to be accompanied by some change of action.

This is not the physical change, but a consequence of the feeling which attends that change; and as it properly belongs to the organ itself, being the exclusive attribute of living matter to feel and move, this I term the vital action.

Now the ultimate effect of any medicinal substance acting upon the body, must depend upon the joint influence of these two causes, which are far from always coinciding

together, but often counteract and modify each other.

To illustrate this, we may take the familiar instance of external cold; which if moderate causes determination of blood to the surface; if excessive produces constriction and paleness; of which paradox the following appears to be the explanation:

All external feelings cause the vessels to endure a greater degree of distension from the blood before they contract; probably from impairing the perception of the distending cause. The external feeling of cold tends, therefore, to produce determination to the surface; but this effect is counteracted by the physical influence, if the cold be excessive, which by its constrictive power overcomes the force of the blood and resists distension of the vessels. The result will of course depend upon modifying circumstances; if the circulation be strong, or the cold inconsiderable, the force of the blood, aided by the external feeling, overcomes the constrictive influence, and determination is the consequence; if the circulation be feeble, or the cold excessive, the physical action over-balances the force of the blood and the effect of the external feeling, and shrinking of the vessels is the result.

A robust country girl, or a person whose circulation is quickened by exercise, will experience therefore a glow or an increased sense of warmth from exposure to a degree of cold that would cause paleness and shrinking in the face of a delicate lady, or a person using no exertion.

Before an inquiry into the action of medicines can lead to any certain or useful conclusions, the following points would require to be ascertained; upon which I believe the science of medicine has little that is satisfactory, and nothing conclusive, to offer.

These points are—first, the nature of organic feelings, and their precise influence in modifying particular functions; secondly, the nature of physical changes, and their precise influence in modifying the effects of the feelings they may give rise to.

From the attainment of these points we might proceed with some confidence to investigate the operation of medicines; but in the present infant state of the science, nothing can be advanced but what is partly conjectural; and whatever is admitted should be received with certain limitations, as all our inferences are liable to undergo considerable modification in a more advanced state of knowledge. It must be allowed, however,

to be a step of no trivial importance, if we succeed in striking into the proper path of inquiry, and contribute something towards directing future adventurers in the way they have to pursue: emboldened therefore by this hope, we may venture to explore this labyrinth in which so many have lost themselves, although we should incur the risk of sharing a similar fate.

Previously to entering upon this investigation, it will be expedient to take a retrospective view of some of the principles formerly deduced, in order to form a more distinct idea of the probable influence of sensible and physical impressions in altering the functions of sensation and motion, and their power of reciprocally modifying each other. For this purpose we must again revert to the nature of the functions themselves.

Sensation consists in the perception of changes going on in our organs; and, as formerly shewn, is liable to variation from moral and physical causes; the latter altering the susceptibility of change, the former varying the degree of attention paid to the impression, and thus altering the power of perception.

Sufficient reason has been shewn for concluding, however, that mental perception in organic impressions is only an occasional ac-

cessary, but never essentially necessary to the faculty of feeling; and employing the term sensation therefore in its widest acceptation, to comprise both conscious and inconscious feelings, this faculty appears liableto variation from whatever renders the organ more or less susceptible of change from physical causes.

Now it must appear, that increased aggregation of the particles composing the living solid, will naturally tend to diminish its susceptibility of change; and on the contrary, impaired cohesion to render it more subject to the influence of physical causes. Accordingly we find that cold, which universally tends to augment the aggregation of particles, diminishes the sensibility, and warmth, which has an opposite tendency, augments the susceptiblility of impression. And all such causes as might be naturally supposed to impair the tone and weaken the cohesion of the living solid, appear from experience to render the body more susceptible of noxious impressions, and more liable to disease—such as poor diet, inanition, want of exercise, depressing passions, &c.; and thus we may perceive a physical reason why morbid sensibility is induced by debilitating causes.

Motion consists in the alternate contrac-

tion and relaxation of the moving fibre; the state of contraction arising from a closer aggregation of its particles, transiently induced by the nervous influence.

Considering motion under this point of view, it must also appear that it is liable to variation from change in the natural tone or density of the moving fibre; and we may trace something like a physical cause for the law formerly deduced, namely, that whatever tends to augment the mobility or range of action, diminishes the power of continued exertion in the moving fibre.

Impaired density in the muscle, arising from a diminution in the number or aggregation of its particles, will naturally augment the extent of contraction they are capable of undergoing from the nervous influence, and will therefore increase its mobility or range of action. But the fewer particles are contained in the fibre, the greater must be the extent to which they are acted upon by the nervous influence to produce a given effect, and the sooner will they have undergone the changes which give rise to the sense of fatigue; and thus the power of permanent exertion will be naturally diminished, while the mobility is increased by impaired density or loss of tone in the muscle.

Accordingly we find, that loss of tone is usually accompanied by morbid irritability or tendency to inordinate action; thus convulsions are liable to occur in extreme debility; vomiting often attends a weak stomach; inflammation proceeds from causes directly or indirectly debilitating to the capillary vessels, as a cut, a burn, a bruise, a sprain, over-exertion, sudden alternation of temperature, &c.; and when the vascular system in general is in a weak and irritable state, fever is induced by any slight irritation; and although we have not yet investigated the precise nature of fever and inflammation, it will be readily admitted that both are chiefly characterized by unusual mobility in the vascular system.

The causes also that induce increased mobility, are the same as those already stated to occasion morbid sensibility, namely, bad air, unwholesome diet, want of exercise, inanition, depressing passions; and thus we may perceive a physical cause for the connexion between debility and spasm, the existence of which has long been admitted as an axiom in pathology.

What reason we have for assigning to any substances a direct power of increasing the aggregation of the living solid, and thence pro-

ducing effects the reverse of debilitating, will constitute the next object of inquiry.

After having carefully analyzed the phenomena of sensible impressions, and ascertained the mode in which the action of different organs is liable to be affected by them ; if we still find phenomena present themselves, which are in direct opposition to the laws deduced, we are almost warranted from this circumstance alone to infer, that some laws of a totally different nature must operate in their production, or that substances do not act merely by the irritation they excite. Fortunately, however, we have no occasion to rest this conclusion upon inferential grounds, as the fact has been already ascertained by direct experiment.

These experiments are not yet laid before the public, although made thirty years ago by one whose name will long be dear to every friend of science—the author of the celebrated theory of animal heat. As I am not at liberty to give a particular account of them, the reader must, for the present, be satisfied with a statement of their general results, which I conceive to be highly interesting.

The object which their author had in view was, to ascertain the power of different physical agents in augmenting the cohesion of the

living solid; for which purpose portions of skin, mucous membrane, nerve, and vessel, were taken from an animal recently killed; immersed in infusions of different medicines, and the comparative strength of these and other portions not immersed in the infusion accurately compared by an instrument ingeniously contrived for the purpose; another instrument was also contrived for dividing exactly equal portions of the same membrane; and by occasionally reversing and varying the experiments, every objection was removed relative to their accuracy.

But it would be objected, that experiments made in this way upon the dead, afford no fair ground for analogy applied to the living fibre.

To obviate this, Dr. Crawford tried to ascertain the influence of the vital principle in modifying the effect, by submitting the membrane, nerve, or vessel, to the same experiments at different periods; and found, by comparison, that the power of the medicine was diminished the longer the experiment was delayed; this effect, whether tonic or relaxant, being greater, the nearer the fibres approached to a state of vitality when the substance was applied. In order to ascertain the effect in a state of perfect vitality, he at length injected the infusion into the stomachs

of animals; and having for this purpose taken two pups of the same litter and equal in size, he tried the relative strength between the membrane exposed and that not exposed to the influence of the solution. And now, by repeated comparison between the result of these and his former experiments, he found the relative effect of the medicine augmented in a still greater degree. On the other hand, by delaying the experiment for a certain time, the medicine seemed to have almost entirely lost its influence; equal portions infused and not infused in it exhibiting the same degree of cohesion.

The results of these experiments were curious. Every medicine belonging to the class usually called tonics, and several not strictly called so, were found to increase (and that in almost exact relation to their tonic power) the cohesion of the mucous membrane and of the blood-vessels, but on the contrary to impair that of the skin. Acids in general were found to have an opposite effect, or to diminish the cohesion of the mucous membrane. Neutral salts were found to increase the cohesion of all parts, and muriat of soda most remarkably; alum on the contrary, had scarcely any effect.

As I believe it is the intention of the au-

thor's brother (to whom I am indebted for the liberty kindly allowed me to avail myself of these results) shortly to lay the whole before the public, I trust the reader will soon have it in his power to satisfy himself of their accuracy by reference to the original; and find sufficient reason to acquiesce in the conclusion, that the living fibre, instead of being, as some have too hastily concluded, wholly insusceptible of physical agency, is in many respects more susceptible of such influence, unless when the feelings excited give rise to actions that resist or modify the impression.

In order to convey a more distinct idea of the manner in which the physical and vital action may tend to counteract and modify each other, it may be expedient briefly to recapitulate some of the laws of sensible impressions, and point out the means we possess of ascertaining the nature of organic feelings.

The existence of feelings which excite no mental perception was allowed to be only an inference drawn from the phenomena. A cause has been applied producing changes that would have excited consciousness, if the mind could perceive it, and an involuntary effort of resistance followed, of which the mind was equally inconscious;—the existence of the feeling cannot be denied from the want

of mental perception, any more than that of the corresponding motion from the want of volition.

For ascertaining the precise nature of feelings or impressions on parts incapable of exciting mental perception, we have only analogy for our guide, and proper allowance must be made for modifying circumstances. The greater delicacy of one organ may render it more susceptible of the same impression than another; thus a substance, whose taste is grateful to the tongue, its odour being equally agreeable to the nose, may give pain to the latter by its actual contact, the more volatile particles being all this delicate organ can bear. By analogy we may infer that the same substance carried down to the mucous membrane of the stomach, will produce an effect analogous to that it occasioned on the mucous membrane of the tongue, though still less sensibly felt, from the declining sensibility of the organ.

The influence of habit, however, must also be taken into account, as constant application or frequent repetition renders impressions indifferent to one organ, while they may be highly displeasing to another unaccustomed to their mode of action. Thus the contents of the stomach in their mixed and half assimi-

lated state would be very displeasing if again applied to the tongue; and even thrown up into the cardia, if their acrimony be such as to excite eructations, they often cause a painful sense of heat, called heart-burn; which the mind did not perceive as long as it was confined to the stomach itself, but which is more sensibly felt as it approaches to organs more amply supplied with cerebral nerves; painful in the œsophagus, this impression would probably be intolerable on the tongue.

The influence of sensible and organic impressions on the vascular system, was reduced in a former part of this inquiry to two general laws,—that internal impressions tend directly to increase, and those which are external to suspend the contraction of vessels,—and reasons were adduced to render it probable that these apparently opposite effects result as a natural consequence from a law still more general,—that two impressions cannot be equally felt at the same instant in the same part.

If it now be considered, that all medicines taken into the stomach are directly applied to an extensive surface of the vascular system, highly susceptible of impression from its continual moisture; and if we reflect upon the important general effects that result from

local changes; we shall see that it is necessary to consider the stomach, not only as an assimilating organ, but also as a vascular surface, or a highly susceptible part of the vascular system. Nor yet must we lose sight of its influence over the sensorium through the medium of its cerebral nerves, by which the mind is made sensible when it undergoes any unusual changes; its energy being roused to the employment of those means which nature has furnished for exciting resistance to noxious impressions, as in the effort of vomiting; but endeavour to assign to each its due share of influence in producing the phenomena that present themselves.

## SECT. II.

# ACTION OF MEDICINES ON THE STOMACH.

THE Stomach selected for illustrating the operation of Medicines. This Organ considered in a two-fold light. First, as a vascular Surface. Operation of Tonics; why they do not excite Intoxication; why they sometimes allay and sometimes excite Fever; why Wine in some cases removes Delirium; why the habitual Use of Tonics debilitates.——Acids; why they allay morbid Heat and Thirst; their Action different from that of Astringents; how sulphuric Acid checks colliquative Sweat; Advantage derived from combining Tonics and Acids.——Soporifics; their Mode of Action; why they first quicken, then retard Circulation; the habitual Use of Anodynes; why it induces morbid Susceptibility.——Digitalis; its Mode of Action inquired into; why it renders the Pulse irregular, retards Circulation, causes Depression of Strength and Spirits; why it increases Secretion; how its Action is directed to particular Organs; why its excessive Exhibition causes Tremors, intermitting Pulse, Nausea, Syncope, Vertigo, Blindness and Paralysis.

AS the operation of medicines is a subject too extensive to be fully discussed without a separate treatise, I shall endeavour to elucidate the principles on which I conceive that investigation should be pursued by directing the inquiry chiefly to a particular organ; and

in conformity with the plan already adopted, select the most complex for this purpose, in hopes of rendering the prosecution of the inquiry to those which are more simple, comparatively easy.

With this view the propriety of selecting the stomach is so obvious, that it will hardly be questioned.

Regarding it as an organ of assimilation, its habitudes have already been considered at some length in treating of nutrition ; and allusion to its influence as a part of the vascular system has been unavoidably made in treating of intoxication and convulsions. We shall now inquire more particularly into its influence as a part of the vascular system, and endeavour to explain some apparent anomalies that result from the sensible and physical impression of substances counteracting or modifying each other.

Under the head of intoxication it was stated that strong sensible impressions, externally applied to the vascular system, cause the vessels to endure a greater degree of distension before they contract ; but the sense of distension at length exceeding the force of the external impression, a more powerful contraction succeeds, and the circulation is locally accelerated. But the rapid participation of the

vascular system in local changes soon augmenting general circulation, intoxication, for reasons before alleged, is the consequence.

We have now to inquire why all strong sensible impressions do not equally produce this effect, as acids and strong bitters; to which the obvious answer is, that their physical action counteracts the effects of their sensible impression. We find that bark and other strong bitters have a direct power of corrugating or constricting the vessels, and this effect limiting their range of action, prevents the local circulation from being increased, and therefore no intoxication results.

But as the effect depends, like that produced by the influence of external cold, upon modifying circumstances; or the relation between the tonic power, the force of the blood, and the strength of the sensible impression; bark, under certain conditions of the body, may cause increased circulation. Thus in active fever, when the circulation and general sensibility are increased, these together overcome the tonic power; hence bark in acute rheumatism is often injurious. But in the chronic stage, when the susceptibility of impression is somewhat diminished, and the force of circulation has subsided from previous evacuations, the tonic power is no longer

overcome by the sensible impression, and it proves a most powerful remedy.

On the same principle, wine, which has also considerable tonic powers, varies in its tendency to excite intoxication, according to circumstances ; producing this effect less readily in the torpid fibre of old age, than when the susceptibility and mobility of youth prevail ; and in the last stage of typhus fever, when the powers of life are almost extinct, the faculties of sensation and motion being alike impaired, the sensible impression of wine has little influence, and its tonic powers alone exert their beneficial effect : it restores the tone, removes the relaxation, and moderates the over-distension of the minute vessels ; and thus suspends the low muttering delirium arising from congestion in the brain, with quick but enfeebled circulation.

It is a curious, and to every medical man a highly interesting inquiry, why tonics, if carried beyond a certain extent, or continued beyond a certain time, often cease to produce their beneficial effect, and appear to do injury rather than service.

Reasoning a priori it might have been presumed, that whether the action of medicines depends upon the feelings they excite, or the direct physical changes they induce, these

could have only a temporary effect; nothing but the natural process of assimilation, with wholesome diet, and proper exercise, being capable of permanently maintaining the tone and vigour of the system. No one, it is presumed, will contend that bark affords nourishment, or that this or any other drug is capable of directly augmenting the vital principle; and as we find from Crawford's experiments, that the tonic powers are increased by the vital influence, we may easily conceive, that if the exhibition of medicine be carried so far as to interfere with the process of nutrition, its salutary influence will soon be impaired or suspended. Instead of aiding the efforts of nature, by substituting an artificial in the place of a natural process, we are rather impeding her operations, and taking the work, as it were, out of her hands. The benefits, however, of a temporary assistance, to enable her to resume her functions, are often conspicuous, as in the advantage frequently derived from a judicious course of purgative medicines; whereas the habitual use of them never fails to impair the tone of the intestines. The remedy should perhaps be only resorted to as the least of two evils, or when it appears calculated to do less injury than habitual constipation, which is seldom removed when

once confirmed. Tonics, on the same principles, if injudiciously employed, or too long continued, may prove injurious instead of beneficial.

Acids also excite a strong sensible impression without inducing intoxication; and a satisfactory explanation of the action of a class of medicines so extensively useful in febrile diseases, would, if attainable, surely be a valuable addition to our knowledge, and is therefore at least deserving of the attempt.

Experience shews them to possess the greatest efficacy in allaying morbid heat and thirst; whence they are termed refrigerants; but this fact, sufficient perhaps for most practical purposes, was not likely to be accounted for before the cause of morbid heat and thirst had been explained.

In a former part of this inquiry we have seen that the sensations of heat and thirst, when combined, are intimately connected with a similar change in the state of the vessels to that inducing intoxication; this latter arising from quick, strong, and full circulation; whereas over-distension of vessels, constricting their mouths and suppressing secretion, causes the former. But as over-distension naturally results from increased force of circulation, one question is involved in the other, and both resolve themselves into this.—why do acids

allay the force of circulation and remove over-distension of vessels ?

As the sensible impression of tonics is counteracted by their physical properties increasing the cohesion of the vessels, and thus limiting their range of action, so we are led to expect some physical property in acids also to counteract their sensible impression; and experiment, which is here our safest guide, suggests, that they relax instead of increasing the cohesion of the fibre; whence we come to inquire whether this may account for the effect produced.

It may not at first appear how opposite causes should produce a similar effect; and when over-distension of vessels originates in loss of tone, we should rather expect a relaxant to aggravate the evil.

Tonics have no remarkable power of increasing secretion; acids have; and this difference may lead us to the solution of the problem.

Tonics, applied equally to the vessels and to their mouths, probably cause an increased contraction in both, and thus remove over-distension, but without augmenting secretion; and hence we may see the propriety of removing plethora previous to their exhibition, without which they frequently aggravate fever.

Acids, applied equally to the vessels and to their mouths, probably cause increased relaxation of both; but relaxation of their mouths necessarily causes depletion of the vessels, and removes their over-distension, at the same time increasing secretion; and hence we may perceive how a similar effect in restoring the vessels to a proper degree of contraction results from opposite causes, and see the propriety of resorting to acids for this purpose, when the circulation is full and strong, as in active fever, and when morbid heat and thirst proceed from increased force of the blood; but in the passive stage, when relaxation of vessels appears to be the chief cause of these symptoms, and when further evacuation is not required, we may see the propriety of administering tonic medicines.

The sense of constriction felt on taking acids into the mouth will probably excite a doubt of their having a relaxant power; but it should be considered that the shrinking of the vessels from the evacuation produced is sufficient to account for this sensation; and it may be further remarked, that simple astringents, as alum, suppress instead of increasing secretion; acids therefore do not act like astringents, as they increase, instead of suppressing secretion. Their beneficial effects, in sup-

pressing hæmorrhage, may be also explained in the same way, from the depletion of vessels they produce; their operation being probably analogous to that of other modes of evacuation to which it is customary to resort.

Sulphuric acid has been so long regarded as a tonic, and employed with that indication to relieve the colliquative sweat that occurs in the last stage of consumption, ascribed to extreme debility, that this acid will no doubt be urged as an exception; but one circumstance renders it highly probable that it is no exception, but a further confirmation of the correctness of the preceding view. Every medical man is aware that this remedy, in checking the colliquative sweat, is liable to bring back the colliquative diarrhæa which usually alternates with it; and thus it appears only to moderate one excretion by increasing another. It is not, however, to be inferred, that under proper management, it may not be advantageously employed to regulate both.

Why acids relax the living fibre we do not pretend to explain; but it is deserving of notice, that all relaxants do not act in the same way; some are transient, others more permanent, and some strictly deleterious in their effects; hence the difference resulting from warmth, acids, and the contagion of fever,

all of which appear relaxant to the living fibre, though materially different in their nature. So also are tonics widely different from each other, both as to the nature and durability of their action; and a correct idea of the disease in which they are employed, can alone guide the practitioner in making a proper selection in the use of them.

The advantage frequently found to result from combining or alternating the exhibition of bark and sulphuric acid has perhaps given rise to the erroneous supposition, that they act upon the same principle; whereas they rather appear to correct each other, and prevent the ill effects likely to result from continuing the separate exhibition of either: bark, by suppressing secretion, being liable to excite fever, while it obviates debility; and acids, while they restore secretion and allay fever, being liable, if long continued, to produce relaxation and debility.

The frequent or habitual use of acids is too obviously relaxant to be denied; debility, paleness, and emaciation, are the usual effects; and although the refrigerant influence of increased secretion may render them often indirectly tonic in febrile diseases with regard to their general effects, it seems highly probable that their physical influence is directly relaxant

to the moving fibre, agreeably to the result of Crawford's experiments.

Viewing the stomach as a vascular surface, the important changes of circulation induced by opium and other soporifics may next be inquired into; and for this purpose it will first be proper to state the precise symptoms to which they appear to give rise.

The first effect that follows from a moderate dose of opium is usually a slight acceleration of pulse, and some degree of exhilaration; these are soon succeeded by slow pulse, heaviness, and sleep which, as already shewn, results from full and slow circulation in the brain.

The general participation of the vascular system in local changes has been already accounted for, and we have only now to inquire into the nature and cause of the local changes.

These cannot be referred to the sensible impression of the drug, as, in the usual dose, it has no sensible impression adequate to account for even the slight acceleration of pulse produced; and the retarded circulation, that rapidly succeeds, is the reverse of what would result from a sensible impression. Nor can these effects be ascribed to a tonic power, as neither intoxication nor sleep would result from such a cause, or bark would equally

give rise to them. Nor yet can they be referred to a directly debilitating influence exerted upon the vessels, because the muscular power is often at first increased rather than impaired by opium; the connexion between the tone of the vessels and that of the muscles having been already pointed out, from whence it appears that loss of tone in vessels is the indirect cause of weakness in the muscles; and over-distension of vessels, from continued muscular exertion, probably the first cause of the sense of fatigue, or the vessels the immediate seat of that sensation. Accordingly we find that a cordial taken into the stomach on the first approach of fatigue, when the action of the vessels begins to languish, instantly recruits the strength and renews the spirits by its direct influence on the vascular system. So far is opium from directly debilitating, that the Turks inebriate themselves with it on going to battle, and thereby increase their strength and courage. We must seek, then, some other cause to explain the phenomena; and experiment, which is generally the safest guide, at least when nature is not tortured into anomalies, points out that opium almost immediately impairs the susceptibility of impression in the organ to which it is applied.

This organ is now the vascular surface of

the stomach, comprising vessels of various classes, their permanency of contractility increasing in an inverse ratio to their size and mobility; the larger contributing more, and the smaller less towards the propulsion of the blood; while the function of the smallest approaches to that of mere transmission and filtration, separating the blood into its more simple elements. As the most minute vessels approach more nearly to the surface, it is reasonable to suppose that they will be first affected by a substance which is superficially applied; and impaired susceptibility of impression, as experience suggests, will be the consequent effect. This will produce a diminished resistance to the distending force of the blood; such being the peculiar function of this class of vessels; a more ready transmission, and more free circulation, will necessarily follow; and we may thus account for the slight acceleration of pulse and exhilaration of spirits that arise, the brain being the first organ to participate in local changes of the vascular system. But the same effect will probably soon extend from smaller vessels to those of larger capacity, whose function contributes less to filtration, and more to propulsion of the blood; and impaired sensibility causing impeded action in these vessels, whe-

ther it arise from sympathetic communication of the changes induced in the former, or the direct influence of the drug applied to themselves, will now produce an opposite effect, namely, retarded circulation; and this supervening upon previous relaxation with congestion in the capillaries, sleep will result, being the natural consequence of full and slow circulation in the brain.

The effects of opium appear, then, most probably to arise, not from its exciting a sensible impression, nor from its exhausting by previous over-action, but from its suspending for a time the perception of organic impressions, and thereby diminishing the mobility of organs whose action depends upon that susceptibility; and the rapid participation of the whole vascular system, without the necessity of supposing the substance to be absorbed and directly conveyed to the brain or other organs affected, accounts for the general effect resulting from the local changes. If, however, absorption should in any degree take place, similar effects would result from its internal application to the vascular system; its influence arising, not from its sensible impression, but from the physical changes it induces, which will in all likelihood be the

same on the same organs, whether it be internally or externally applied.

To inquire why opium suspends for a time the susceptibility of impression in the organ to which it is applied, may perhaps be regarded as carrying speculation too far; but the principles formerly suggested may enable us to conceive the possibility of accounting for it. As feelings arise from changes that are going on in the organs, the peculiar kind, or durable nature of those it induces, may prevent the organ from being susceptible of others until the former have been obliterated.

The habitual use of opium, or other anodynes, brings on at length a morbid susceptibility of impression; an effect directly opposite to that which its immediate operation produces; and the following may be assigned as the cause of it.

After the body has been frequently accustomed to the soothing influence of this drug, which diminishes for a certain time the perception of every displeasing impression, thus indirectly diffusing a calm tranquillity through the whole system, the returning susceptibility, when the influence of the anodyne ceases, is doubly felt from the contrast. As the sudden changes from dark to light, from heat to cold, excite uneasy sensations; or as a person

habituated to the tranquil silence of the country is distracted at first by the noise of the metropolis; so if the perception of corporeal feelings be continually blunted, their natural impression at length ceases to be habitual; impressions that should be insensible from their continuance, become novel and strange from suspension; mental perception begins to attend them; the order of nature is inverted; organic assume the character of animal functions, and the mind is disquieted by a thousand corporeal feelings, that never before attracted attention.

Relief is now only to be obtained by again having recourse to the anodyne; and the miserable victim aggravates the cause of his sufferance by the means from which he derives a temporary remission of it.

Analogous to this is the effect resulting from the habitual use of intoxicants taken to excess; the constant experience of their exhilarating influence renders intolerable the void and depression that succeed; and the vascular system inured by constant habit to a state of morbid distension, suffers a change of tone, and a change of general irritability is the consequence. A countenance ruddy and inflated, an eye red and fiery, and an unusual irascibility of temper, are the first indications of this revolution.

The remarkable influence of digitalis on the circulation does not properly belong to the consideration of effects produced on the stomach as a vascular surface, since the mode in which this drug is administered so as to produce these effects, shews that the stomach is not the direct seat of the impression. But as the inquiry will tend to throw additional light upon the subject, and afford an opportunity of contrasting the influence of two substances, which some appear to regard as bearing a near affinity to each other, we may deviate a little from systematic order, and introduce the inquiry here, which might with more propriety have been reserved for another occasion.

When digitalis is exhibited in sufficient doses to act directly upon the stomach, the usual consequence is vomiting, and its operation in this respect does not materially differ from that of other emetics; which will be considered hereafter. Administered so as to act upon the circulation exclusively, it must be slowly and cautiously introduced into the system so as to allow it to be absorbed and carried into the blood, where it acts internally upon the organs whose function exhibits the effects of its influence, namely, those of circulation and secretion.

We shall first consider its influence on the function of circulation.

The comparison instituted at the beginning of this chapter between digitalis and opium, may afford some assistance in the present investigation. We see here nothing like an anodyne effect, or the power of suspending impressions and allaying pain in this drug; but, on the contrary, rather a tendency to excite than allay irritation. Nor, if assumed, would an anodyne effect explain the symptoms it induces: if its nature accord with opium, so should its effects; but digitalis neither allays pain, nor promotes sleep, nor does it render the pulse full, as opium does; but, on the contrary, small and weak. A moment's reflection may also convince us that its effects are no way analogous to those of tonics, as it induces depression and debility, rather than increased vigour; nor yet can we ascribe them to a directly debilitating influence, as diminution of tone causes, in the first instance, increase of mobility, and this in the vascular system would rather accelerate than retard circulation; while relaxation of vessels would not give rise to a small, but a full pulse. Let us then inquire, as experiment shews it to possess irritating power, whether the irrita-

tion excited may be adequate to the explanation of the phenomena.

The irritating cause is gradually introduced and internally applied to the vascular system, where its operation will be equally exerted upon all vessels capable of receiving it. But admitting this, will the influence of its impression be equally felt by all classes of vessels?—Most probably not, as we find that a larger dose of the same medicine is required to affect one organ than is sufficient to act upon another; and again, as the extremities of nerves and vessels are usually found to have the most susceptibility of impression, there is every reason to suppose that the more minute vessels will be the first to experience its influence.

The effect of internal irritation is to excite resistance, or increased contraction; but if the cause operate equally on all classes of vessels, will the mode of resistance be alike in all? Certainly not, as the mode of action peculiar to each class of moving fibres continues still to characterize it under the influence of morbid impressions.

The cause being then equally applied to arteries and capillaries, the latter, which scarcely exhibit any sensible pulsation or mobility from the distending impulse of the

blood, although it is from every pulsation of the heart varying in degree, are still less likely to exert an interrupted resistance to a mode of irritation that is permanent and uniform in its application. The arteries, on the contrary, accustomed to a periodic action, corresponding to the alternate application and removal of the distending force of the blood, will still retain, to a certain extent, their natural mode of action, and exert their usual mobility, though perhaps with less regularity, in resisting an impression that is permanent instead of periodic in its application. From these circumstances the following effects will ensue:—diminished area or increased contraction in the capillary vessels, which exert a more permanent resistance to internal irritation, and this will produce opposite effects to their relaxation; and the one, as was stated in the effect of opium, tending to facilitate, the other will to obstruct the transmission of the blood; and retarded circulation will follow. But the cause being introduced into the blood will operate upon all the capillaries; and those of the heart will participate in the effect; and the irritability of every organ varying with the quantity and velocity of the blood circulating in its capillary vessels, expulsion of blood from

the coronary system will impair the energy of the heart, and thus will the circulation be rendered weaker as well as slower; but the same change, in the mode of irritation applied to the larger vessels, will give rise to some degree of irregularity also in their action, and this will tend to render the pulse occasionally intermitting.

Paleness with depression of strength and spirits will result from the changes in the capillary vessels of the brain, the surface, and the organs of loco-motion; and thus we may account, upon general principles, for all the effects of digitalis upon the circulation.

We shall next consider its influence on the organs of secretion.

The changes of secretion are easily explained. It was found to be a general law, that whatever increases the contraction of exhaling or excreting vessels relaxes their mouths, and therefore increased secretion is the natural consequence of internal irritation; which is one of the most frequent effects that result from the slow and gradual exhibition of digitalis.

It may be asked perhaps, by what means the physician is enabled to direct its action to one organ more than another, so as either to

increase secretion, excite diuresis, or moderate the force of circulation at pleasure; and the following consideration may perhaps throw some light on this curious circumstance.

The weakest organ is naturally, as before illustrated, the most susceptible of an unusual impression, and therefore most likely to be first affected by an irritating cause; and this is fortunately the very organ we in general have to act upon; though we are apt to refer the influence of the drug to one indirectly participating, instead of the direct seat of the impression. Thus when it causes diuresis in the removal of dropsy, it is supposed to act exclusively on the kidneys, and thus cure the disease; whereas it is more probable that the flow of urine is the consequence, and not the cause of the removal of the disease; the medicine acting upon the small vessels in general, and by subjecting them to a new mode of irritation, stimulating them to fresh efforts of contraction, by which they throw off part of the load that oppresses them, and recover from that torpid state which characterizes them in this affection.

We may next inquire into the effects of the excessive exhibition of this drug, or its too long continuance; the symptoms of which are tre-

mors, intermitting pulse, fainting, nausea and vomiting, and perhaps at length vertigo, blindness, or paralysis.

Every moving fibre has a degree and power of action that is natural to it ; and although by habit this may be gradually augmented, such changes cannot be suddenly induced without risk of giving rise to morbid effects; and, if an organ be stimulated to efforts greater than it is able to bear, increased relaxation and debility necessarily follow. Now when the patient is using little bodily exertion, and the pressure of the blood removed by the recumbent posture, the capillary system may bear to be excited to some increase of contraction without producing morbid effects, provided the change be cautiously and gradually brought about. But inordinate contraction and its consequences will be liable to result if such changes be suddenly attempted. The brain and stomach, being in the natural condition of the body the first organs to participate in change of circulation, will exhibit the first symptoms of inordinate constriction in their capillary system : impaired energy and altered function of these organs will be the consequence. This will produce tremors and syncope in the former, as already account-

ed for; nausea and vomiting, as hereafter to be explained, by its operation on the latter.

But inordinate contraction being succeeded by inordinate relaxation, vertigo, blindness, convulsions, and perhaps afterwards paralysis from effusion, may result from the subsequent change in the minute vessels of the brain. If the action of the medicine be determined by constitutional weakness to some other organ, local inflammation may possibly ensue. And thus the effects may all be reduced to general principles.

To demand why digitalis is irritating to our organs, or why all modes of irritation do not produce the same effects, would be an unreasonable expectation. We are not called upon to explain why sugar is sweet, or lemon acid,—nor would this explanation equally contribute to enlarge our stock of useful knowledge; an objection that cannot be urged against the preceding investigation, as it every way tends to correct our reasonings, and to infuse a due degree of caution into our practice. There can, however, be no impropriety in suggesting, that those substances, agreeably to principles formerly deduced, are best calculated to excite irritation, which cause the most rapid changes in our organs.

## SECT. III.

# ACTION OF MEDICINES ON THE STOMACH.

ACTION of Medicines on the Stomach, considered as an Assimilating Organ.——Statement of the Difficulties that occur in explaining the Operation of Emetics.——Cause of Nausea, and its Connexion with increased Secretion from the Stomach inquired into.——How Vomiting arises from Substances increasing Secretion.—How it is excited by Substances not increasing Secretion.—How it is produced when Emetics are injected into the Blood-vessels.——How produced by mental Emotions.——How excited by a Blow on the Stomach.——Cause of Sea-sickness.——Why irritating the Fauces promotes Vomiting.——Purgatives; some Hints for explaining their Mode of Action; why most effectual when compounded.——Conclusion.

WE now proceed to examine the influence of medicines on the stomach, considered as an organ of digestion, or as one calculated from its peculiar organization to receive and assimilate such substances as admit of assimilation, and to reject such as are unfit for the purposes of life.

These faculties are not to be ascribed to a peculiar intelligence in the organ, but to the

influence of the general principle, that the living fibre contracts from a painful, and relaxes from a grateful impression ; the former state rendering it less sensible of pain, and the latter more susceptible of pleasure. This is not alleged as the physical, but as the final cause of the contraction of the living fibre: we must however rest satisfied with a final cause somewhere.

From the influence of these principles (their effect being modified by the structure and function of the organ) result all the phenomena of assimilation and digestion, whether they depend upon altered secretion, or altered action in the assimilating organ. As both these are illustrated in the operation of emetics, the mode of action peculiar to this class of medicines may now be inquired into.

It has been formerly stated as a general law, that internal irritation excites increased resistance in the organs; and the effect of emetics on the stomach was adduced as one instance in illustration of this law. But the phenomena of vomiting are not of so simple a nature as to be fully explained by this principle alone. Other organs besides the stomach are concerned in it, and as these are far removed from the direct seat of the impression, belonging to the class of animal rather

than organic functions, their co-operation requires to be accounted for. As those organs whose co-operation is requisite to produce the act of vomition, namely, the diaphragm and abdominal muscles, are under the control of the sensorium, some change is required that is capable of exciting mental perception, or at least of inconsciously rousing the energy of the cerebral system to co-operate in resisting a noxious impression.

Now many of the causes that excite vomiting neither appear from the force or peculiar nature of their sensible impression to be capable of producing this effect; it is therefore incumbent upon us to explain how an impression not sensibly felt, even by the more perceptive surface of the tongue, may produce such changes in the stomach as to alter its natural action, rouse the co-operation of the sensorium, and throw the whole system into a convulsive effort of resistance.

To say that substances not irritating to the tongue may be so to the stomach, would be begging the question, unless some adequate reason be alleged. It is true, that the contents of the stomach in their half-assimilated state, are often irritating when thrown up into the cardia, and probably would be still more so, if applied to the tongue; but the circum-

stance of their being thrown up proves them to have been irritating also to the stomach; and if they were otherwise, the influence of habit reconciles the stomach to that which is continually applied to it, but habit cannot be alleged as a cause for emetics having lost their power of irritating the tongue. And analogy must still be admitted as our safest guide in judging of the nature of organic feelings.

Having now stated the difficulties attending this formidable problem, we shall meet it fairly, and endeavour to solve them.

Vomiting is produced in such a variety of ways, that to reconcile the operation of so many different causes has hitherto baffled research; and the failure of the attempt is indirectly acknowledged, when we are reduced to the necessity of ascribing it to some specific action, or in other words, some occult quality in the drug, determining its action to a particular organ, and regulating the mode of resistance excited.

But the assumption of an occult quality is in many cases inadmissible. We cannot ascribe any specific action or occult quality to simple warm water, to the motion of a swing, or to the sight of a disgusting object; and yet all these causes occasionally excite vo-

miting: and that explanation is not satisfactory which is not applicable to every cause, and consistent with every phenomenon.

Let us then consider the phenomena of vomiting, and see what presents itself.

In every instance, where vomiting does not arise from the direct application of a strongly irritating impression, or from a morbid increase of irritability in the organ, rendering it more susceptible of impression, as under inflammation, some degree of nausea precedes it; and an increased secretion from the surface of the mucous membrane so constantly attends nausea, that we cannot doubt but some intimate connexion subsists between them. Perhaps the causes of increased secretion may lead us to the nature of this connexion.

Increased secretion will arise, as repeatedly shewn, either from primary relaxation of the mouths of the secreting vessels, or increased contraction of the vessels indirectly relaxing their mouths; it may therefore result sometimes from the one, and sometimes from the other.

If then we suppose it to arise from primary relaxation of their mouths, we have to inquire how that effect may be brought about; and the principles already deduced lead us to

infer, that this may result either from the physical, or sensible action of medicines; as the relaxing influence of warm water, or the external irritation of ipecacuanha.

If it arise from an irritating cause, (and most emetics have a disagreeable taste) why, it may be asked, does one mode of irritation produce it and another not? In order to produce this effect, it is not only necessary that the irritating cause should relax the mouths of the vessels, but that it should not in any remarkable degree relax the vessels themselves by its external impression; as the immoderate relaxation of the vessels themselves was shewn to bring on a constriction of their mouths, and thus suppress the secretion again.

An irritation peculiar in kind or degree appears requisite then for promoting increased secretion; and as parts different in structure vary in their degree of sensibility, it is not improbable that the mouths may be often affected by causes too slight to affect the vessels themselves; the mouth of every excretory duct bearing testimony to the truth of the principle, that extremities are the most sensible parts of nerves and vessels.

But the same reasoning will equally apply to a physical cause; thus the relaxing influence of warm water may open the mouths to

a certain degree, and increase secretion; but if its temperature be greatly augmented, the inordinate relaxation of the vessels may increase the irritation of distension applied to their mouths, to a sufficient degree to cause their contraction, and thus suspend secretion.

But increased secretion may also arise from primary contraction of the secreting vessels relaxing their mouths, probably rendering the secretion at the same time thinner as well as more copious. Now this effect will also proceed from an irritating cause, if internally applied; but it is requisite that the irritation be not so great as immoderately to constrict the vessels, or the fluids may be prevented from arriving at the mouths, and thus secretion be suppressed, as in the cold fit of ague.

The same effect may in some cases also result from a physical cause capable of increasing the contraction of the vessels; and this, if they have been previously relaxed and overdistended, to a sufficient degree to suppress secretion, may again restore them to a proper condition for resuming their functions.

Having then explained the mode in which increased secretion may result from the sensible impression or physical action of medicines, we return to the connexion between this effect

and the production of nausea; and the first consideration that suggests itself is, that nausea does not always accompany increased secretion, and therefore is not the consequence of it, but of some collateral circumstance that sometimes does, and sometimes does not attend it.

In speaking of nausea it was remarked, that this sensation does not consist merely in the sensible impression of the substance taken into the stomach; as the sense of nausea continues the same, varying in degree rather than in kind, although induced by fifty different substances, bearing no relation or affinity to each other in sensible qualities. It must therefore consist in some change in the natural action or condition of the organs, equally occasioned by them all. The nature of this change, and why it arises from such various causes, is then the next point to be ascertained; and for this purpose we must take a nearer survey of the organization and attributes of the stomach itself.

The stomach is a muscular bag, capable of accommodating its capacity to the quantity of its contents. It is lined with a highly vascular membrane, which distends as the organ distends, and shrinks as its bulk decreases; and it admits of a doubt, whether this mem-

brane in the natural state be ever folded or wrinkled to any considerable extent.

By what means does this membrane accommodate itself so readily to the state of the organ? When the grateful impression of food relaxes, as its bulk distends, the stomach, the same impression relaxes the vessels, and allows them to become both distended and elongated; and thus, as the organ increases in bulk, (though it may at first appear singular,) the membrane at the same time increases both in extent and in thickness: the additional supply of blood required to fill this increased capacity of the vessels being probably derived, as before explained, from the compression of the spleen partially diverting the blood from its former course.

When the stomach collapses again, from the rapid absorption of the more fluid parts of the ingesta, what causes this membrane to shrink with the decreasing bulk of the organ? The peristaltic motion cannot be deemed adequate to the production of this effect. The muscular fibres of the stomach may indeed contract it into folds or wrinkles, but cannot produce that uniform diminution of its extent and thickness which appears to keep pace with the decrease of its contents. The obvious and only adequate cause for such

an effect is the depletion of its vessels, proceeding from the increased secretion or exhalation going on from its surface; while the decreasing bulk of the organ is gradually withdrawing the additional supply of blood, by taking off the compression of the spleen, and suffering it to flow back into its former channel. From this cause will the vessels shrink, and with their shrinking will the membrane which is composed of them also collapse, and thus accommodate itself to the size of the stomach, if it may not even contribute towards promoting the uniform depletion of the organ.

If direct proof be required that shrinking of the vessels will cause shrinking of this membrane, let the familiar effect of external cold constricting the vessels of the skin be considered; the shrinking of the uterus from the constriction of its vessels; or the remarkable collapse of the features and surface in the cold fit of ague; and particularly the powerful effect produced upon parts that oppose resistance, as the head, whence the shrinking of the scalp excites a sensation, like that of a cord tied tight round the head. Other instances will not fail also to suggest themselves, which sufficiently prove the influence of constriction of the minute vessels,

in causing a forcible shrinking in a membrane almost entirely composed of minute vessels.

We now return to the production of nausea; which, as stated before, is the perception of an inverted, and perhaps, from its affinity to hunger, of an inordinate action in the muscular fibres of the stomach; and this change in the action of the organ seems to result from an increased secretion, only when this is attended by too sudden a constriction of the secreting vessels.

In the natural and ordinary process of digestion this is slowly and gradually induced, nausea therefore does not result; and yet as hunger approaches, a sensation nearly akin to nausea is often experienced. When the secretion is increased by taking food, the compression of the spleen giving an additional supply of blood, prevents the vessels from collapsing; and the impression of food operates in the same way, its external impression relaxing the vessels in proportion to the increase of secretion. But when this increase of secretion arises from direct relaxation of the mouths, without any pleasing or external impression to relax the vessels themselves, and without any circumstance to afford an adequate supply of blood and prevent

collapse, a shrinking of the vessels will necessarily ensue; and such a change, unless the vessels were previously over-distended, appears to be always attended with an unpleasant sensation. Hence the disagreeable impression that arises from hæmorrhage, syncope, and the cold fit of ague; and hence probably the natural aversion we feel for cold, which constricts the vessels,—and our predilection for warmth, which induces an opposite effect. We might perhaps go even so far as to allege, that the sense of heat or cold does not consist in the immediate perception of altered temperature, but of the concomitant and corresponding changes in the state of the vessels that result from it; as the sensation bears a much more uniform relation to these changes than to the change of temperature itself; a variety of causes that alter the state of the vessels giving rise to an altered sense of heat and cold, without any real change of temperature.

Now this sudden change in the condition of the membrane producing an unpleasant impression, alters the action of the organ and gives rise to the sense of nausea: and thus we have explained how a substance, not obviously disagreeable to the tongue, may excite unpleasant changes in the stomach, and

thus alter its natural action; or how a substance that does not make us sick because it is disagreeable, may be disagreeable because it makes us sick.

But we have not yet completed the solution of the problem. Nausea does not always precede vomiting, and when it does, an altered condition and inverted motion of the stomach are not means adequate to the expulsion of its contents in a violent and spasmodic manner. This effort requires the aid of parts under the control of the sensorium, as the diaphragm and abdominal muscles; which, by compressing together the whole of the abdominal viscera, propel their contents upwards or downwards, and cause thereby a general evacuation of the whole system of organs and vessels subservient to the function of assimilation.

This co-operation may be induced in the following manner:—The general participation of the vascular system, evinced by the paleness, shrinking, and cold sweat that precede vomiting, may first excite mental perception of the changes going on; and the increasing sense of nausea, or the sensible impression of the substance, if one be produced on the stomach, will soon direct the attention to the seat of the evil, and rouse the energy of the sensorium, either voluntarily or invo-

luntarily to exert those means which nature has given, and instinct points out, as best calculated to remove the offending cause.

On these principles then, may we explain the production of vomiting, and the operation of all causes giving rise to this effect.

When emetics are injected into the blood, the brain and stomach are the first organs after the lungs to which they will be carried; and whether they act by constricting the vessels, or relaxing their mouths, they will soon be directly applied to both; internal irritation constricting the vessels, and thence relaxing the mouths, as external irritation before relaxed the mouths, and thence constricted the vessels.

If the cause be inadequate to excite vomiting, as a weaker irritation is sufficient to excite purging, this effect will probably follow; if not, diuresis or diaphoresis may result; all explicable on the same principles.

It is not even necessary for the medicine to arrive at the stomach in order to excite vomiting; if the change it induces in the vessels in general be sufficiently rapid and considerable, vomiting may result from the participation of distant parts of the capillary system in local changes, and those of the stomach will partake of the general effect.

Thus vomiting occurs from mental emotions which have any relation to disgust, though acting primarily on the vessels of the brain; thus it occurs spontaneously in the cold fit of ague, from the general constriction of vessels; and in the same way nausea arises from hæmorrhage, causing a collapse of the vessels; and the cold sweat of fear, on similar principles, often excites sickness at the stomach.

There are also some mechanical causes which excite vomiting, and a few remarks upon them before we dismiss the subject will be hardly deemed foreign to the purpose, though not strictly belonging to the physical agents employed in the practice of medicine.

A blow on the stomach subjects this organ to a mode of internal irritation, which is not very ambiguous; as stamping on a bladder, filled with fluid or vapour, tends to burst it, so is the stomach suddenly over-distended by the blow; and thus is internal irritation excited, though the cause be external.

The motion of a swing, or that of a ship, is less simple in its operation, but seems to admit of explanation in the following manner: The contents of the stomach being alternately thrown from one side of the organ to another, or from the lower to the upper surface, when the vessel either rolls or pitches,

as it is termed, may cause an unusual impression, and thus increase the secretion to such a degree as to excite nausea, agreeably to the principles before stated; which is confirmed in some measure by the excessive flow of saliva sympathetically occasioned from the mouth, and the intolerable sense of nausea accompanying it. But there is another circumstance which has probably more weight, and this is the motion of the organ itself. Every person who has experienced sea-sickness is aware, that the pitching of the vessel is the most intolerable, and the subsidence or descent of it in particular, during which moment the contents of the stomach appear to be rising spontaneously towards the mouth, and what is termed the heaving of the stomach is produced. As the two extremities of this organ are more fixed, while a certain degree of motion or play is allowed to its central parts, which motion is actually communicated to it in the act of vomiting; so is this same motion to a certain extent produced by the alternate rise and fall of the vessel; and this coincidence, accompanied by an increased secretion, altering the condition of the organ, seems sufficient to account for a propensity to vomiting.

Irritating the fauces promotes, if it do not sometimes actually produce this effect.

From the continuity of connexion, and similarity of structure, between the mucous membrane of the fauces and that of the stomach, we may conceive the ready participation of the one in an impression made upon the other; and the community of function between the fauces and muscles of respiration, which are immediately concerned in the act of vomiting, may further promote this effect. The functions, in which both these organs are habitually connected, are swallowing, sneezing, coughing, smelling, yawning, and vomiting; and this association being directed in a particular mode by the influence of attention and volition, and strengthened by repetition, may at length produce a spontaneous power of exciting the action of one organ by irritating the other. When a person wishes to vomit by irritating the fauces, he naturally tries at the same time to imitate this action, and to fancy a degree of nausea at the stomach, which obviously tends to promote the effect, and probably contributes very materially to its production.

The operation of purgatives, diuretics, and diaphoretics, can hardly suggest any serious difficulties, if the foregoing principles have been well understood; and the limits of an elementary work would not allow us to enter

into them with the same degree of minuteness. The following remarks may however facilitate the inquiry:

Purgatives are for the most part of the same nature as emetics, only require to be exhibited in smaller doses. They are almost always attended with an increase of secretion from the membrane lining the intestinal canal; is it not probable, that this is accompanied with some diminution in the capacity of the canal from the shrinking of the secreting vessels, and mucous membrane? And may not this contribute to the propulsion of the contents, and the expulsion of air, the sudden generation of which it is less easy to account for, than the sudden diminution of capacity in the organ that contained it.

Purgatives are found by experience to act best when compounded; and this combination is generally formed by adding to a substance producing increased secretion, one of strong sensible impression, as aromatic powder, ginger, Cayenne pepper, &c. The benefit usually ascribed to this addition is, that it prevents griping, and causes the purgative to act more pleasantly; an expression of the fact, rather than an explanation of the cause.

The length of this canal precludes the possibility of its sudden and instantaneous

depletion, like that of the stomach, produced by vomiting. A more regular and uniform increase of the peristaltic motion seems requisite for this purpose; may it not be supposed then, that while one substance physically relaxes the mouths of the exhalents, and thereby lubricates the passage, at the same time that it tends to contract the area of the canal,—the other, by its sensible impression, increases the peristaltic motion, and thereby promotes the transmission of the ingesta?

If this be the case, the great difficulty found in compounding purgatives so as to act properly, and produce an evacuation without griping, or too copious a discharge of serous fluid, may arise from the nicety required in adjusting the proportions; so that the one shall not counteract the other, or by too strong a sensible impression, over-distend the vessels and constrict their mouths, thus suppressing secretion again.

As purgatives and emetics both remain some time in the organ before their full effect is produced, is it not probable that absorption takes place in both cases; and that they augment the excretion by their internal impression on the vessels, as well as their external action on the mouths?

There are yet many interesting inquiries

that might be suggested, which do not properly fall within the limits of the present work: and the extended application of the doctrines it contains might be deemed premature, before the fate of the principles themselves now brought before the tribunal of the public has been in some measure decided.

The author is far from sanguine in his expectations, that doctrines so new as some advanced in the preceding pages will be readily acquiesced in by men who are previously attached to different opinions. In an undertaking of so extensive a nature, he is well aware that his views may have been occasionally too partial, and his reasonings sometimes fallacious; and that a more copious induction of facts than that from which his inferences were drawn, may hereafter materially modify some of his conclusions.

Whatever errors may be pointed out, a candid avowal of them is an atonement he will always be ready to make: fully sensible that the final establishment of doctrines applicable to every possible variety of disease, and capable of explaining every phenomenon of life, can only be attained by "the assemblage of numberless converging rays from an extensive circumference."

Let the fate of his opinions be what it may,

he hopes he may have manifested some zeal in the search after truth; and trusts he may be allowed to have pursued a mode of inquiry which can never retard, should it have failed in advancing, the progress of science.

# Explanation of the Plates.

## PLATE I.

### FIG. 1.

REPRESENTS a vertical section of the skull containing the brain, &c.

A A A—The edge of the bones of the cranium.
B B—The brain or cerebrum.
C—The little brain or cerebellum.
D—The medulla oblongata, being the commencement of the spinal marrow.
E E E—The bones of the face.
F F—The falciform process.
G—The division between the lateral ventricles.

### FIG. 2.

Represents the brain and cerebellum taken out of the skull, and turned up to shew the origin of the nerves, which are numbered.

## PLATE II.

Represents a back view of the muscles, after the integuments have been removed.

## PLATE III.

Represents a front view of the skeleton.

## PLATE IV.

### FIG. 1.

Represents the eye surrounded by its muscles; and exhibits a view of the distribution of the different nerves supplying that organ, which are numbered.

a b c—The first, second, and third branches of the fifth pair of nerves, arising from a ganglion, called gasserion (No. 5.)

d—The lachrymal gland, supplied from the third branch (c) of the fifth pair.

e—A filament from the same branch going to the forehead.

### FIG. 2.

Represents an outline of the eye-ball, surrounded by the muscles.

1 2 3—The margin of the orbit.

a—The ball of the eye.

b—A muscle that goes to the upper eye-lid.

c d—Muscles of the eye-ball.

e—The patheticus muscle, or trochlear passing through the pulley.

f—The optic nerve.

### FIG. 3.

A horizontal section of the eye, including the optic nerve; shewing the different membranes surrounding the ball; the relative situation of the chrystalline lens, placed behind the cornea and iris, and partially covered by the ciliary processes. The ciliary processes were not noticed in the description of the eye, for the same reason that prompted the omission of several other points of minute anatomy, namely, their use not being sufficiently known to throw light upon the function of the organs. The ciliary processes are radiated fibres lying immediately under, and running nearly in a similar direction to those of the iris. They surround, and partially cover the margin of the chrystalline lens, and are usually regarded as a continuation of the internal layer of the choroid coat, as the iris was formerly of the external layer of the same membrane.

a—The sclerotic coat.

b—The choroid.

c—The retina.

d—The cornea.

e—The chrystalline lens.

f f—The ciliary processes.

g—The anterior chamber between the cornea and iris, con-

taining the aqueous fluid. There is also a second chamber between the iris and lens, too small to be represented.

h—The vitreous humour filling nearly the whole of the posterior cavity of the eye.

i i—The iris.

FIG. 4.

The outline of an interior view of the anterior half of the same organ perpendicularly divided. The cut edges of the different membranes are seen; the chrystalline lens, and ciliary processes, appear through the remaining portion of the vitreous humour.

a—The sclerotic coat.
b—The choroid, with the pigment over its surface.
c—The retina, its cut edge folding inwards.
d—The ciliary processes.
f—The iris.
g—The pupil.

FIG. 5.

Outline of an external view of the choroid coat, the sclerotic being removed. The vessels are seen ramified through it, and the junction of the iris with the choroid is shewn on the anterior surface, with the pupil in the centre.

a—The choroid coat, with its vessels
b—The remains of the sclerotic.
c—The iris and pupil.
d—The optic nerve.

FIG. 6.

A representation of the anterior and external surface of the same figure.

a—The surface of the choroid.
b—The radiated fibres of the iris.
c—The circular ring of the iris.
d—The pupil.

FIG. 7.

A view of the retina, the other membranes being removed. The

lens is seen partially covered by the ciliary processes, as explained in fig. 3; the arteries of the retina are seen ramified upon it.

a—The retina.
b—The lens.
c—The ciliary processes.
d—The optic nerve.

### FIG. 8.

An anterior and external view of the same plate.

a—The ciliary processes.
b—The chrystalline lens.

## PLATE V.

Represents two views of the internal organ of hearing, about the natural size. In order to convey a distinct idea of the different canals contained in the centre of the temporal bone, all the intervening substance of the bone is supposed to be filed away, leaving the vestibule cochlea and semicircular canals with only a thin shell around them, to maintain the integrity of their different cavities.

### FIG. 1.

Shews the auricle, and external orifice or meatus auditorius externus detached from the head. At the bottom of it is seen the internal surface of the membrane of the drum, with the vestibule cochlea and canals beside it, and the small bones contained within the drum in the natural state, but here exposed to view by the removal of the sides of this cavity.

a—The internal surface of the membrana tympani.
b—Part of the bony rim to which it is attached.
c—The outer surface of the vestibule.
d—The outer surface of the cochlea.
e e e—The outer surfaces of the semicircular canals.
f—The small bones communicating from the inner surface of the membrane to the finestra ovalis of the vestibule, which is covered by one of the bones called stapis, from its resemblance to the form of a stirrup.

g—The small bones separately represented below. A distinct idea of their connexion could not be given without a very minute description, which would be inconsistent with the plan of a mere outline of the organs.

FIG. 2.

Shews the situation of the internal organ of hearing in the base of the cranium. This organ is seen from above, an outline being given of half the base of the skull, containing the ear of the right side excavated in the manner already described.

A—The fore part of the cranium, with part of the nasal bones.
B—The back of the skull, or occipital bone.
C—The cribriform plate, through which the olfactory nerve passes.
D—The foramen magnum, which receives the spinal marrow.
E—The external orifice of the ear, entering the temporal bone.

## PLATE VI.

Represents the organs of voice viewed from behind, by opening the back of the pharynx. The opening of the nostrils into the throat, the posterior aperture of the mouth, and the entrance of the larynx and pharynx are thus exposed to view.

A A—The cut edges of the pharynx.
B B—The nostrils, opening into the throat.
C—The uvula.
D—The back surface of the tongue.
E—The epiglottis.
F—The entrance to the glottis.
G—The larynx
H H—The trachea, or wind-pipe.
I—The pharynx, terminating in the œsophagus.

## PLATE VII.

Represents the relative situation of the thoracic and abdominal viscera, by opening the integuments, and removing the front of the pleura and peritoneum, the omentum, &c.

A—The heart.
B—The right auricle.
C—The pulmonary artery.
D—The commencement of the aorta.
E—The vena cava superior.
F F—The jugular veins.
H—The angle formed by the jugular and subclavian veins, the thoracic duct joining with them from behind.
I I—The lungs.
K K—The divided edge of the midriffe, or diaphragm.
L L—The liver.
M—The stomach.
N—The spleen.
O—The gall-bladder.
P P P—The intestines.

## PLATE VIII.

Represents a plan of the abdominal viscera, the liver being turned up to shew the situation of the gall bladder and pancreas, with their respective ducts entering the duodenum a little below the pylorus.

A A—The liver turned up.
B—The stomach.
C—The gall-bladder.
D—The biliary and pancreatic ducts entering the duodenum.
E—The situation of the pancreas shewn by the dotted line behind the stomach.
F F—The duodenum.
G G G—The jejunum.
H H H—The ileum.
I—The termination of the ileum.
K—The caput cæcum.
L—The vermiform process.
M M M—The great arch of the colon, and one of its ligamentous bands.
N—The sigmoid flexure of the colon.
O—The rectum.

FINIS.

Printed by G. F. Harris's Widow and Brothers, Liverpool.